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MONTHLY WEATHER REVIEW

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GAP WINDS OF THE STRAIT OF JUAN DE FUCA

By THOMAS R. REED

[Weather Bureau office, San Francisco, Calif., July 17, 1931]

The easterly gales at the west end of the Strait of Juan de Fuca constitute one of the notable climatic eccentricities of the North American Continent. Indeed it may not be extravagant to claim for them a position unique among the winds of the world. The writer knows nothing in meteorological literature which describes their counterpart, although winds of similar type though less violent are common to many other localities. The type (for it is believed these winds belong to a distinct type) undoubtedly reaches its culmination at or near Cape Flattery, Wash., at the entrance to the Strait of Juan de Fuca. This strait affords the principal sea-level egress for air evicted by gravity from the drainage basin of Puget and Washington Sounds. It lies in a nearly east-west direction and is about 75 miles long. At its western end it opens into the Pacific Ocean, and at its eastern end into Puget and Washington Sounds. It is walled on the north by the mountains of Vancouver Island and on the south by the Olympic Mountains. The basin into which the strait leads is flanked on the east by the Cascade Range and on the west by the Coast Range, including the Olympics.

Fortunately for the needs of investigation, the Weather Bureau is provided with ample observational data at this point, a fully equipped station having been maintained at Tatoosh Island, near the cape, for many years. The exposure of the wind instruments is good. They are located 113 feet above mean sea-level at a point where the island reaches a height of 80 feet above the sea. The island is described in Henry's "Climatology of the United States" as "a rock standing 75 to 100 feet above the ocean, three-fourths of a mile directly west of Cape Flattery, and at the mouth of the Strait of Juan de Fuca. With a rolling surface, it covers an area of a little less than 17 acres. The sides are precipitous. There are no trees or buildings that in any way interfere with the exposure of the instruments." The Weather Bureau installation is in the center of the island.

The frequency of easterly gales at Tatoosh Island is recognized by forecasters of the Weather Bureau, but it is doubtful if many of them have noted the individual and extraordinary character of these gales. Desiring to secure information in this regard, the writer appealed a few years ago to the Weather Bureau official at Tatoosh Island for a statement of the total number of easterly winds of 40 miles per hour or over which had been recorded there in the 5-year period, 1923–1927, inclusive. His answer stated that of 450 gales, all directions considered, which were recorded during that period, 219 were from an easterly quarter. Eleven of these gales were from the northeast, and three from the southeast. The remaining 205 were due east, an average of 1 in every 9 days for the 5-year period. When it is realized that the vast majority of these winds occurred during the winter season, the percentage of frequency for that time of year becomes more impressive still. The circumstance, however, which makes them especially worthy of note is not their frequency but their origin. They are not, properly speaking, gradient winds. That is to say, they do not approximate even remotely as a rule the air-flow requisite to balance the pressure gradient. Neither can they be classed as katabatic.

In support of the assertion that they are not gradient winds, considerable evidence has been adduced. Seventy-five cases have been considered. They include all easterly gales of 50 m. p. h., or over, which occurred during the inclusive period 1924–1927. Winds for 1923 were dropped out of the investigation because of the inadequacy of information touching the pressure situation at sea prior to 1924, information which could not be ignored in a discussion of coastal winds without casting doubt on the conclusions.

Also, it was decided to eliminate from consideration velocities of less than 50 m. p. h., since this economy of material would make the data more manageable without sacrificing any facts essential to correct deductions. Furthermore, it should be noted that all velocities are from records of the 4-cup anemometer; hence the adoption of 50 m. p. h. as the minimum to be considered really eliminates only winds of less than actual gale force, since the true velocity in miles per hour corresponding to 50 miles indicated on the 4-cup anemometer is 39.7 miles, or approximately the minimum that could be classed as a gale in Beaufort's terminology. It should be explained further that the 75 cases coming under this classification refer to the number of dates involved, not the number of individual gales; in several cases the gales extended over a period of two or more days, while in others they occurred on a single night both before and after midnight, thus requiring their entry as of two calendar days.

First let the statement that these winds are not ordinary pressure gradient phenomena be considered. While casual inspection of the synoptic charts for almost any of the dates involved would lead to this assumption, the writer sought to eliminate any grounds for contention by preparing a detailed table of pertinent data covering each instance. The table gave a full list of easterly gales at Tatoosh Island with dates of occurrence and set forth adjacent thereto maximum wind velocities and directions on concurrent dates at the four Weather Bureau stations nearest to Tatoosh, namely, Port Angeles situated on the strait about 63 miles eastsoutheast of Tatoosh; Seattle and Tacoma situated on the east side of

Puget Sound about 124 miles and 133 miles, respectively, southeast of Tatoosh; and North Head situated on a promontory of the coast 150 miles south of Tatoosh. Maximum winds recorded in the log of the Swiftsure Bank Lightship, anchored about 15 miles northwest of Tatoosh, also formed a part of the table.

No rigid inspection of the statistics was needed to convince one of the peculiar nature of Tatoosh winds, or to dissociate them from essentially pressure gradient phenomena. First were considered the maximum winds which occurred over Puget Sound on the dates when easterly gales were registered at Tatoosh. In only three cases did these winds reach gale force (40 m. p. h.) at Tacoma, and in only five at Seattle. Taking 50 miles as representing a gale for these stations, as was done for Tatoosh, the contrast was more striking yet. Only 1 such gale occurred at Tacoma and only 2 at Seattle, as against 75 at Tatoosh. None was recorded at Port Angeles. The mean velocity of the 75 maximum winds at Tatoosh was 60 m. p. h., at Tacoma 20 m. p. h., at Seattle 23 m. p. h., and at Port Angeles 16 m. p. h.

Significant as these comparisons are, they are rendered still more so when directions are considered. All the gales at Tatoosh were due east. If they were strictly gradient winds it would be natural to look for predominant easterly components in the winds occurring simultaneously over the region from which they were directly supplied, or which might be considered as their immediate source. This emphatically was not so. At Tacoma only 11 per cent of the maximum velocities had any easterly component whatever, at Seattle only 37 per cent, and at Port Angeles, where none might expect the greatest preponderance of due-east directions because of its location at the eastern end of the identical strait on which Tatoosh is situated, only 47 per cent showed an easterly component, while there were numerous cases of southwesterly directions and a few from the northwest. Of the two blows at Seattle which exceeded 50 m. p. h., the direction in one case was southwest and the other south. The one blow at Tacoma which exceeded 50 m. p. h. was from the southwest. On the same dates the maximum wind at Port Angeles was 24 m. p. h. southwest and 24 m. p. h. north, respectively.

These facts certainly disposed of any presumption that the Tatoosh gales are dependent on a general and marked pressure gradient over the immediate hinterland, if that term may be used to delimit the basin which incloses the waters of Puget and Washington Sounds. However, lest any doubt lurk on this point (the vagaries of surface wind movement over rugged country and landlocked waters being freely admitted) examination was made of the actual pressure gradient between the interior and the coast on the dates in question. The mean pressure difference at 5 p. m. between Seattle and Tatoosh, an air-line distance of about 124 miles, for the 75 days on which easterly gales occurred at the latter station, was 0.09 inch. This to be sure did not represent pressure differences computed for the exact moments at which extreme velocities were reached at Tatoosh. The labor involved in such research was too great to impose on the men employed in meteorological duties there and at Seattle. It did, nevertheless, furnish a serviceable approximation, the convincing nature of which was enhanced by considering individual cases. Thus, for example, three instances were found of no pressure difference between the two stations, and four where the gradient was negative; that is, *higher at Tatoosh than at Seattle*. While the wind had subsided to some extent in every case, and in two had undergone radical change in direction at 5 p. m. when the pressure observations were made, five of the seven instances were very remarkable, the wind continuing from an easterly quarter at Tatoosh at a velocity which ranged between 18 and 38 m. p. h. Here, indeed, is interesting material for the student of pressure-gradient phenomena.

The foregoing, while disposing of any assumption of an inland pressure gradient steep enough to account in itself for the easterly gales at Tatoosh, takes no cognizance of what may have been the pressure situation at sea at such times. The query naturally arises: Should we expect to find a pressure gradient offshore steep enough to account for the extraordinary gale phenomena at the cape? The answer is in the affirmative only if we consider the gales under discussion as belonging to a distinct type—an orographic or so-called bottle-neck type. An investigation was made of the barometric pressure over an extensive network of stations in the Pacific Northwest at the approximate time the gales listed were in progress. In most cases data secured from 5 p. m. (Pacific time) observations sufficed. In a few cases, however, 5 a. m. data were employed. Pressure data for numerous points at sea were obtained by interpolation from manuscript weather charts on file at the San Francisco office of the Weather Bureau, prepared from observations taken on shipboard a trifle earlier than at the land stations, viz, 4 a. m. or 4 p. m., Pacific time.

A cursory examination of these data confirmed the natural expectation of finding conditions best for an easterly gale at Tatoosh when the pressure is abnormally high to the northeast and low to the southwest. Closer inspection, however, revealed the inadequacy of pressure gradients therein to account per se for the velocities which actually occurred, even in the relatively few instances which called for winds of gale force over the open sea. That the pressure situation both on land and at sea contributed indirectly to the gales at Tatoosh is not questioned; that it did so in such a way as to entitle them to classification as gradient winds is denied.

In support of this denial there is additional testimony. A composite isobaric chart was constructed, presenting means of the pressure data referred to above. This chart, while confirming the observation that high pressure to the northeast and low pressure to the southwest of Tatoosh are the ideal conditions for easterly blows at that point, also demonstrated by the very weakness of the composite gradient the fact that such blows may occur under the most diverse individual conditions of pressure distribution. In other words, it appeared that easterly gales may occur at Tatoosh with the lowest pressure in any of the three sectors, north, south, or west. There were 35 dates when the lowest pressure was to the southwest of Tatoosh, 27 when the lowest pressure was to the northwest, 8 when it was lowest at Eureka, Calif., and 1 when it was lowest at Kamloops, British Columbia. The preparation of charts more closely synchronized with the time of occurrence of the peak winds might change these figures somewhat; nevertheless it is believed the ratios would remain substantially the same.

Comparison of winds at the two nearest coastal observation points was made: At Estevan, located on the southwest side of Vancouver Island 110 miles northwest of Tatoosh, and at North Head, situated on the Washington coast 150 miles south of Tatoosh. Maximum wind data were not obtainable for Estevan, but current wind data reported at the time of the regular 5 a. m. and 5 p. m. observations were compiled from entries on the pencil charts at San Francisco. These showed 14 instances of a calm at Estevan when the wind was blowing

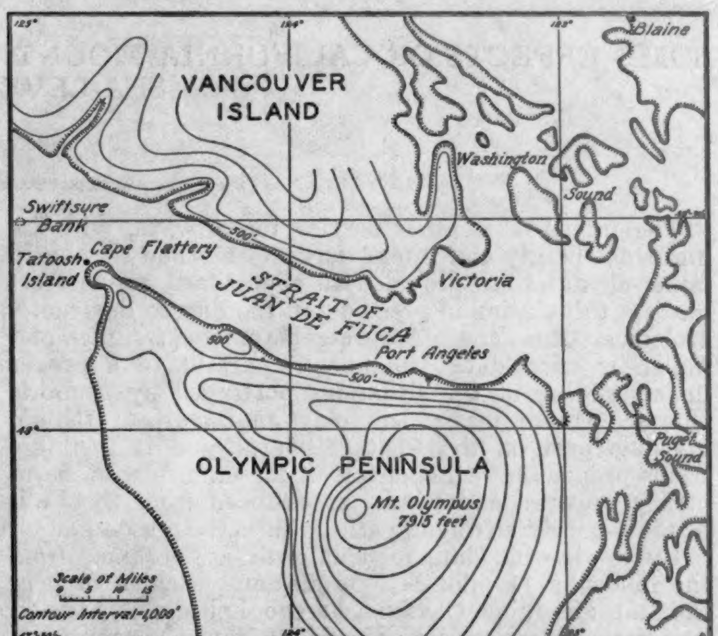
out of the strait at Tatoosh Island at a rate of anywhere from 18 to 76 miles per hour. In only 3 out of 14 cases was the velocity at Tatoosh less than 40 m. p. h. Significant, too, was the great variety of directions recorded at Estevan at other times. In the 71 cases investigated (Estevan reports were missing on 4 dates) all but 6 showed due east winds at Tatoosh, and an average velocity for all of 38 m. p. h. Simultaneously, Estevan showed, in addition to the 14 calms mentioned, numerous cases of winds from the north, northwest, and west, with a mean velocity of 8 m. p. h.

Passing from the coast nortwest of Tatoosh to that lying south of it, wind figures for North Head were examined. Here maximum velocities were available. North Head offers the best exposure for the registration of gradient winds of any of the stations for which data are submitted, as it is situated on a promontory of the southern Washington coast 250 feet above the sea. Moreover, this station lies in the same climatic zone as Tatoosh and storms that affect one usually affect both. It is recognized that orographic influences tend to accentuate the velocity of the wind at North Head, and that many more gales are recorded there than would be found in that vicinity at sea. This is not only a logical inference, but one frequently confirmed by radiographic weather reports from ships in the offing. Nevertheless North Head offers as good an exposure for the registration of gradient winds, both direction and velocity considered, as could be found in that section of the coast. It is especially valuable in connection with this study, as storms that produce southerly gales at Tatoosh are almost certain to produce as high or higher velocities at North Head. The percentage of gale frequency is the same for both. During the period 1923–1927 inclusive there were 450 gales of all directions at Tatoosh and 440 at North Head. Gales at North Head as a rule are obviously related to the pressure gradient at sea, while a substantial percentage of those at Tatoosh are not. Of the 75 dates on which easterly gales of 50 m. p. h. or over were recorded at Tatoosh, the maximum wind at North Head was from the east on only 32, with a mean velocity for the 32 occasions of 27 m. p. h. The direction on most of the other dates was from the south. The mean velocity at North Head for all directions was 39 m. p. h.

A survey of the foregoing evidence, while disposing of the inference that the Tatoosh gales are pressure gradient phenomena in the strict sense of that term, leaves untouched the question of their relation to the horizontal temperature gradient. Can they be classed as katabatic? Almost as many easterly gales were recorded at Tatoosh with the temperature above normal over Puget Sound as with the temperature below normal. Nor does it appear absolutely necessary to have the air in the interior colder than at sea, as witness the blows of June 25, 1925, and September 18, 1927. On the latter date the highest temperature of record for that time of year, 76°, occurred at Tatoosh, and even higher temperatures were recorded in the interior; while on the former date still more extreme conditions prevailed, the highest temperatures ever recorded there being reached at both Seattle and Tacoma.

The vagaries of wind direction and velocity introduced by irregularities in the terrain are admitted. It may be suggested therefore, that easterly gales at Tatoosh are frequently of a quite local character and do not reflect wind conditions even a few miles out in the channel. The records of the Swiftsure Bank Lightship were studied and gave a strong indorsement to the reliability of Tatoosh data as representing the general wind movement out of the strait. These records, though not obtained by instrumental means, are believed to represent very conservative estimates. In the opinion of the lightship master they are much more likely to be underestimates than overestimates of wind force. Moreover, they actually represent only the highest force noted at observations taken at two hour intervals, i. e., at 2, 4, 6, 8, etc., o'clock. Velocities between times may have been higher although allowed to pass without note. With this in mind it was recognized that the wind movement near the middle entrance of the strait where the lightship is anchored, fully 15 miles northwest of Tatoosh, agreed remarkably well with the easterly gale data for Tatoosh itself. There were 42 days when the force (Beaufort scale) exceeded 7, and the average force for the 75 cases was between 7 and 8. The winds, therefore, are not a vagary peculiar to the sides of the strait, but obtain in mid-channel as well.

In seeking to account for this phenomenon, obviously we must look elsewhere than to a marked pressure or temperature gradient for the explanation. That the



winds are fundamentally due to difference in air pressure between the interior regions and the sea is evident, although this difference may not be expressed as a pressure gradient in the vicinity of Tatoosh or the Strait of Juan de Fuca. Admitting that the pressure difference exists, however, as between the air mass over the interior and that at sea, the peculiar manner of outflow arising from such difference rather that the amount of the difference must account very largely for the extraordinary rate of movement of the air at and near the point of ejection. It must be peculiarly an orographic phenomenon, originating in a pressure inequality and varying as the degree of such inequality, but deriving its remarkable velocity from the converging sides of the channel through which it makes its way.

The physiographical conditions for the production of such winds at Tatoosh are ideal. The drainage basin which includes Puget and Washington Sounds furnishes the reservoir for a vast body of air of nearly homogeneous density. The converging terrestrial walls flanking the Strait of Juan de Fuca constitute the funnel through which the bulk of this air must flow at the behest of

lower pressure at sea. The contracting channel acting like a Venturi tube increases the speed of the flow until by the time the gap at the point of ejection is reached extraordinary velocities are attained.

Winds similar in type if not in strength are to be found wherever the character of the terrain restricts to some gap or gorge the passage of air from regions of higher to regions of lower pressure. They are a common orographic phenomenon of the moving air. For this reason some special term to define and describe them seems to be demanded. Maj. E. H. Bowie has suggested the name "bottleneck winds." "Funnel winds" was used some years ago by Mr. S. L. Trotter in a paper dealing with marked incongruities in gale velocities at certain observation points on the Atlantic coast.[1] The writer has already employed the term "orographic" in referring to such winds, although in the opinion of some it is open to objection as being too general. "Gap winds" is sufficiently specific and is favored by at least one meteorologist of eminence.[2] "Orographic" would, it is true, apply to a wider variety of winds than any of the other terms suggested. It would describe winds which increase in velocity by passing *over* a mountain barrier equally as well as those which increase in velocity by passing *through* a gap or gorge. Both phenomena deserve appropriate nomenclature. They are so characteristic of the moving air as to have become a commonplace of airway weather observations in mountain districts. They occur in such regions with a consistency which would be surprising if the cause were less obvious. Orographic winds, whether of the gorge, gap, or ridge variety, are obeying in principle if not in detail the law exhibited in the functioning of a wind tunnel or a Venturi tube. In the gorge, three sides of a Venturi are roughly represented; in the ridge but one. But the constriction affecting the flow operates effectively, though in varying degree, in all cases. Indeed the term "Venturi winds" may be offered without doing violence to logic.

[1] Local Peculiarities of Wind Velocity and Movement Atlantic Seaboard—Eastport, Me., to Jacksonville, Fla., by Spencer Lee Trotter. Page 634, vol. 48, Monthly Weather Review.

[2] In a marginal comment on the author's manuscript, Prof. W. J. Humphreys wrote: "Orographic winds is not good—it is too general. Why not 'Gap winds?' That is what they are. I have a vague impression that this term has been used."

SOME EFFECTS OF CALIFORNIA MOUNTAIN BARRIERS ON UPPER AIR WINDS AND SEA-LEVEL ISOBARS

By DELBERT M. LITTLE

[Weather Bureau Airport Station, Okland, Calif., August 17, 1931]

The intensive weather service for airways, with its numerous hourly and three-hourly reports and six-hourly upper-air data, has provided an opportunity for meteorologists to examine in great detail the day to day meteorological situations. Accurate barometer readings and upper-air wind data are most important to a proper understanding of the situations portrayed by synoptic charts. Mountain barriers play an important though invisible part on the weather charts, and it therefore seems proper that some effects of these barriers on barometric pressure and winds, as deduced from the California 3-hourly airways weather charts, be presented.

Upper-air wind data for California are obtained from the following 11 pilot balloon stations, each in or near the State: Redding, Oakland, Fresno, Lebec, Los Angeles, San Diego, March Field (Riverside), Santa Maria, Reno, Nev., Yuma, Ariz., and Medford, Oreg. Of these, 7 are Weather Bureau stations, 2 Signal Corps stations, 1 a Navy station, and 1 privately maintained but cooperating with the Weather Bureau.

Of the California 3-hourly reporting stations, 15 use the mercurial barometer and are located in or just beyond the State at the following places: Eureka, Redding, Oakland, San Jose, Fresno, Bakersfield, Lebec, Estero, Los Angeles, San Diego, March Field (Riverside), Tonopah, Nev., Reno, Nev., Phoenix, Ariz., and Medford, Oreg. Reports also are received from a number of stations to the east and north of the last four named. In addition, there are 30 stations in California reporting pressure from aneroid barometers. Readings from aneroid barometers at first were of little value, (*a*) because of their uncertain height above sea level and (*b*) because of slowly changing instrumental errors. Eventually a plan was worked out to establish arbitrary corrections, to be revised from time to time, for reduction to sea level of all readings from aneroid barometers at low-elevation stations, i. e., stations less than 400 feet above sea level. Each arbitrary correction was based upon the departure of the aneroid reading from an interpolated value secured from the regular 8 a. m. and 8 p. m. seventy-fifth meridian time charts at times when "flat" pressure maps are evident and *no strong upper air winds prevailed.*

For each aneroid barometer at a high elevation a reduction table was secured from a Weather Bureau station whose elevation was approximately the same as the aneroid to be reduced. Then a small arbitrary correction was determined by the method of interpolation described above in order to fit the aneroid reading very closely to the reduction table. Arbitrary corrections are changed by a new interpolated value from time to time, thus very nearly eliminating any error due to seasonal march of temperature or changed instrumental error. It is safe to say that ordinarily the accuracy of these aneroid reductions is to within 0.03 inch of the true sea-level pressure values. With one-third of the barometers of the mercurial type well distributed over the State, it is not at all difficult to detect errors in and adjust readings of the aneroids at other stations in the network.

Approximately 50 airway and off-airway reports are entered every three hours on a base map printed from a plate of the Stanford relief model of California. The valleys and mountain ranges stand out in striking contrast to aid the meteorologist in determining the effect of the terrain on weather, as well as to visually aid pilots seeking advice as to the weather over the airway. Some of the salient facts noted on the synoptic maps are as follows:

1. Exceptionally steep pressure gradients at times prevail over mountain barriers and the isobars very frequently follow the mountains in a general way, but not exactly parallel to elevation contours.

2. In cases of extreme pressure gradients, the upper air winds immediately over the barriers are of strong to hurricane force and at nearly *right angles* to the sea-level isobars along the mountains.

3. The surface barometric pressure is increased on the windward side and decreased on the leeward side of mountain barriers in comparison with pressures reported at considerable distances from the mountains.

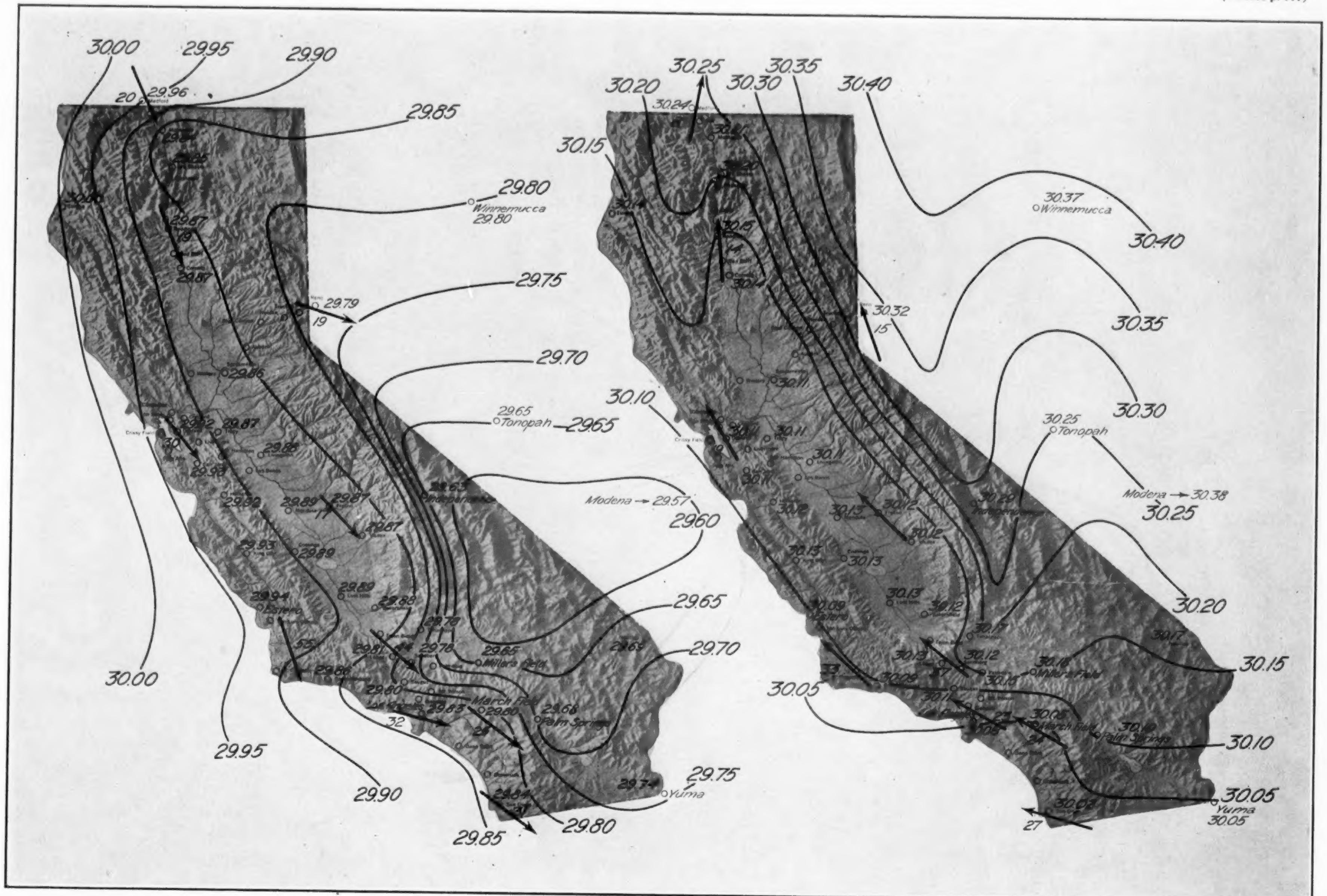


FIGURE 1.—Composite sea-level pressure maps for nine cases of extreme low pressure at Independence, Calif., in relation to Fresno, Calif., and nine cases of extreme high pressure at Independence, Calif., in relation to Fresno, Calif., during the period November, 1930, to March, 1931, with average upper air winds at 6,500 feet to 8,000 feet above sea level

4. A trough of low pressure forms rapidly in the lee of a mountain barrier as upper air winds increase in velocity in crossing the barrier.

5. The trough of low pressure on the leeward side of the mountain barrier persists for many hours after the center of the depression has passed away from the vicinity of the barrier.

Some of the best examples of extreme pressure gradients over mountain barriers in the United States are found in the Rocky Mountain States. Extreme differences in the temperatures of the air masses on the opposite sides of these mountain barriers often largely account for the differences in the computed sea-level air pressures. However, there are many cases where differences in the temperatures of the two air masses do not wholly account for the extreme pressure gradients over the mountain barriers. This was particularly noted on the California airways weather charts when, during the late fall and winter seasons, temperature differences on the slopes of the Sierra Nevada and Tehachapi ranges often were small.

Many meteorologists are familiar with the occasional large differences in the reduced (to sea-level) barometric pressures between Fresno to the west of the Sierra Nevada and Independence to the east. Some have been inclined to disregard the Independence barometer reading on the assumption that it was in error, or was faulty due to abnormal temperature. The writer studied the Independence barograph traces from November, 1930, to April, 1931, and checked them against the observed mercurial barometer readings and the reductions to sea level. Many unimportant differences in the mean temperature argument between Independence and Fresno were noted. It was found that personal errors do not enter into the reduced (to sea-level) barometric data for Independence and that the data are quite as accurate as those received from any other Plateau station, yet they appear to be more erratic. The elevation of Independence is 3,957 feet, which is somewhat lower than the average Plateau station.

Nine cases of extreme low pressure and nine cases of extreme high pressure at Independence in relation to Fresno were selected from the charts of November, 1930, to March, 1931, inclusive. Composite pressure maps for the nine cases of each type of pressure distribution were prepared as shown on Figure 1. All of the aneroid and mercurial sea-level barometric data received from the airways reports were used. Isobars were drawn for each 0.05 inch of pressure to bring out the pressure gradients over California in more detail. From inspection of the upper air winds shown on the maps for the several days selected, it was evident that northwest and west-northwest winds were associated with relatively low pressure at Independence, and southeast or east-southeast winds with relatively high pressure. The average velocity and direction of the winds at 6,500 to 8,000 feet above sea level were plotted on each map in Figure 1.

In order to determine whether there was a relation between the velocity of the upper air winds and the pressure gradient between Independence and Fresno, the upper air wind data at Lebec (elevation above sea level, 3,576 feet) were selected as being most typical. The upper air winds for Fresno were not used because of the topographic or shielding effect of the Sierra Nevada. East to southeast winds were selected because of the absence of stormy weather during their prevalence and consequent completeness of the upper air data. Resultant velocities were computed for each minute of observation for 45 balloon runs with east to southeast winds of moderate to gale velocities at Lebec during November, 1930, to March, 1931. The graph of these resultant velocities at Lebec indicates that the winds reached the highest velocities at altitudes ranging between 5,700 and 7,400 feet above sea level, and attained from the fourth to sixth minutes of the balloon run. The individual data for these altitudes, then, should be the most significant in determining whether a relation exists between east to southeast wind velocities over the mountain barrier and the high pressure at Independence. Ninety-five cases during the period referred to were used in which the Independence sea-level pressure was higher than that at Fresno and the upper air winds from the fourth to the sixth minute observation at Lebec were from the east to southeast. Using these selected data, the table of averages shows that with increasing velocity of the wind the pressure becomes higher at Independence than at Fresno.

Average velocities in miles per hour of east and southeast winds for the fourth to sixth minutes of balloon runs at Lebec, Calif., during November 1930, to March 1931

Sea-level barometer at Independence higher than at Fresno by—	Difference in mean temperature argument Independence and Fresno	
	84 cases of 0° to 13° F.	11 cases of over 13° F.
	Miles per hour	*Miles per hour*
0.04 to 0.06 inch	14	13
0.07 to 0.11 inch	23	15
0.12 to 0.17 inch	27	22
Over 0.17 inch	35	20

We are not in the habit of thinking that winds cause a pressure gradient but rather that a pressure gradient causes winds. However, when an air mass is flowing over a mountain barrier, undoubtedly there is a tendancy toward compression on the windward side and an expansion on the leeward side of the mountain. An abnormal pressure gradient in the vicinity of the barrier results. It might be argued that the air is free to rise vertically and a compression could not exist, but there is undoubtedly a restraining force due to the increased momentum of successive layers of air involved. It might also be argued that the data in the table could be transposed to prove that the winds are gradient winds caused solely by the pressure gradient. If this is the case, then it is not apparent how the belt of slightly excessive pressure along the east side of the Sierra Nevada is maintained for several days at a time, except by the explanation of wind action against the mountain barrier, i. e., compression. (See the map at the right in fig. 1.)

A similar phenomenon occurs along the shore line of California, Oregon, and Washington when on-shore winds prevail.[1] It is at times particularly marked because there is no coastal plain, and fairly steep mountain ranges parallel the shore line from southern California to the Canadian border. As long as the winds in the lower layers of the atmosphere are southeasterly the phenomenon is not apparent on our maps, the "refrac-

[1] Sir Napier Shaw, Manual of Meterology, Vol. IV (Part IV) pages 98–99.

There is moreover another reason why a station on the coast presents a complication in the relation of observed wind to gradient which may be operative in windy weather when the local gradient of temperature is not very marked. This second reason is the dynamical effect upon the stream of air due to the sudden transition between a surface with a comparatively low coefficient of eddy viscosity, such as the sea, and one with a comparatively high coefficient, such as a land surface, particularly a hilly or rugged land surface. This change must probably be represented by a sudden transition of pressure in the surface layers which produces a "refraction" of the isobaric lines on crossing the coast. * * * The mere addition of the volume of the land to that of the air which passes over it must produce some increase of the pressure at sea level.

tion" probably being slightly reversed with winds off shore at an acute angle, but as soon as a cyclone in the north approaches the Canadian coast and the winds veer, the phenomenon appears on our airways maps and becomes more marked as the winds veer to westsouthwesterly. This "refraction" of the isobaric lines therefore gives us immediately knowledge that the winds are veering during periods of stormy weather with the cyclone to the north and usually with upper air data missing. This is a distinct aid in forecasting airway weather conditions for short periods in advance.

Compression effect on the windward side of a mountain barrier does not fully explain its counterpart, namely the barometric troughs on the leeward side. In order to have a better understanding of the entire phenomenon, it would be of advantage to know, in a general way, how air flows over a mountain barrier. With single theodolite balloon runs, it is not possible to determine, from the individual runs at Lebec, the amount of vertical component in the lower levels and whether at some average

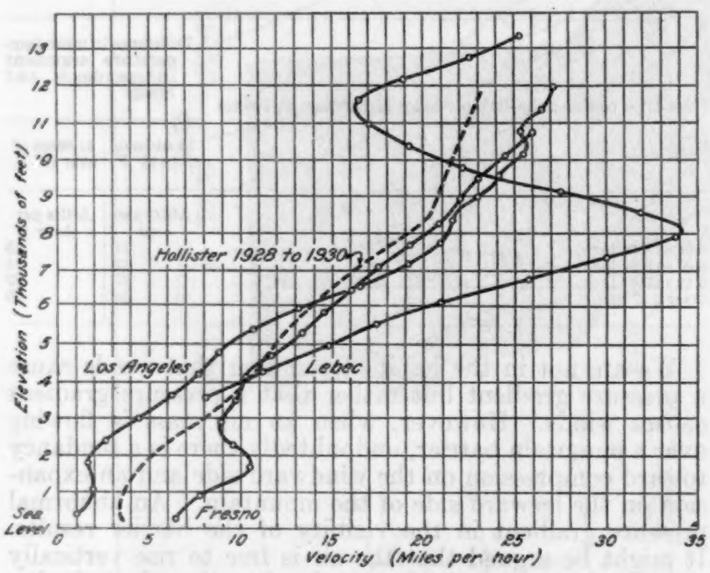


FIGURE 2.—Resultant velocities of north northwest and northwest winds over Fresno, Lebec, and Los Angeles, Calif., during the period November, 1930, to March, 1931, inclusive. Resultants computed from 71 to 85 runs nearly simultaneously, at the three stations with data nearly complete to the highest altitudes

altitude there ceases to be a vertical component to the winds over the mountain barrier. However, some interesting evidence bearing on this question has been obtained by comparison of graphs of resultant velocities for west-northwest to north-northwest winds at Lebec and surrounding pilot-balloon stations.

Graphs of resultant velocities over Fresno, Lebec, and Los Angeles for all cases of west-northwest to north-northwest winds over central and southern California during November, 1930, to March, 1931, inclusive, were prepared (see figure 2), from data which were nearly complete to 12,000 feet above sea level. The resultant directions were, of course, northwest to north-northwest or nearly parallel to a line running through Fresno, Lebec, and Los Angeles. The graph for Lebec shows extreme velocities at about 8,000 feet above sea level. A decided change in slope of the curve for Los Angeles at about 8,000 feet above sea level, and a faint bulge in the curve for Fresno at about the same elevation stand out prominently. A similar resultant velocity graph for Santa Maria with less data available shows a decided change in the slope of the curve at slightly above 8,000 feet. Data from short balloon runs were discarded in computing these resultants and the data are 90 per cent complete at the highest levels.

To prove that the changes in the slopes of curves at 8,000 feet were not peculiar to the period selected, 188 cases of north to west-northwest winds over Hollister, Calif., from October, 1928, to September, 1930, were used and the resultants computed. The data were 95 per cent complete to the highest level, all short runs being discarded. A decided change in slope of the curve for Hollister at 8,000 feet above sea level is shown. From these graphs it appears that practically all topographical retardation in velocity of northwest winds over the Tehachapi and coastal ranges of mountains has been eliminated at 8,000 feet above sea level.

It is important to note that only two or three peaks in these ranges of mountains extend to 8,000 feet.

It should not be assumed that most of the air when moving southeastward over the San Joaquin Valley below the mountain barriers, is forced upward and crosses the Tehachapi Mountains. This is not the case, for the balloon runs for Fresno show that on numerous occasions a large anticlockwise eddy, with vertical axis, at elevations averaging between 2,000 and 5,000 feet above sea level, while winds near the surface and above these altitudes are moderate to strong north to northwesterly. This great valley eddy is not always marked by winds of opposite direction at those levels over Fresno, but its effect on often noted in the marked decrease in velocity of north to northwest winds at those levels. This is important from an aircraft pilot's standpoint as he may often escape the full effect of northwest head winds by flying at about 3,000 feet along the eastern side of the San Joaquin Valley.

The resultant velocities of northwesterly winds at elevations between 6,500 and 11,000 feet above sea level over Fresno are approximately equal to the resultant velocities at corresponding elevations over Los Angeles. The resultant velocities for similar winds over Lebec, in the Tehachapi Mountains, do not show this similarity because of the extreme velocities at 8,000 feet above sea level. A somewhat striking chart of the extreme velocities of the northwest winds is obtained by plotting a series of individual balloon runs on a single graph. (See fig. 3.) The extreme velocities of air flowing over a mountain barrier may be explained by assuming that the velocity increases as a considerable portion of the air passes through a restricted outlet. Part of the abnormal velocities observed at this level may be fictitious and due to insufficient rise of the balloon on entering the rapidly-moving air stream, but if there is any upward vertical component to the air, which seems possible because Lebec is on the north slope of the range, the error would be minimized.

Similar graphs of the resultant velocities of southwesterly winds over Fresno and Reno (see fig. 4) show the maximum velocities over the Sierra Nevada, as indicated by the Reno graph, at about 11,500 feet above sea level. The average height of the Sierra Nevada west of Reno is approximately 3,000 feet greater than the average height of the Tehachapi. This accounts for the greater height above sea level of the extreme velocities observed over the mountain barrier at Reno than over that at Lebec.

The increased velocity of the free air, immediately over mountain barriers, then, no doubt causes decreased pressure on the leeward side of the barriers. This phenomenon may be said to be similar to the decreased pressure on the upper surface of an airfoil in flight,[2] the mountain

[2] For an excellent explanation of this phenomenon see "A Philosophy of Lift" by H. F. Lusk, MS. published in United States Air Services, March, 1931.

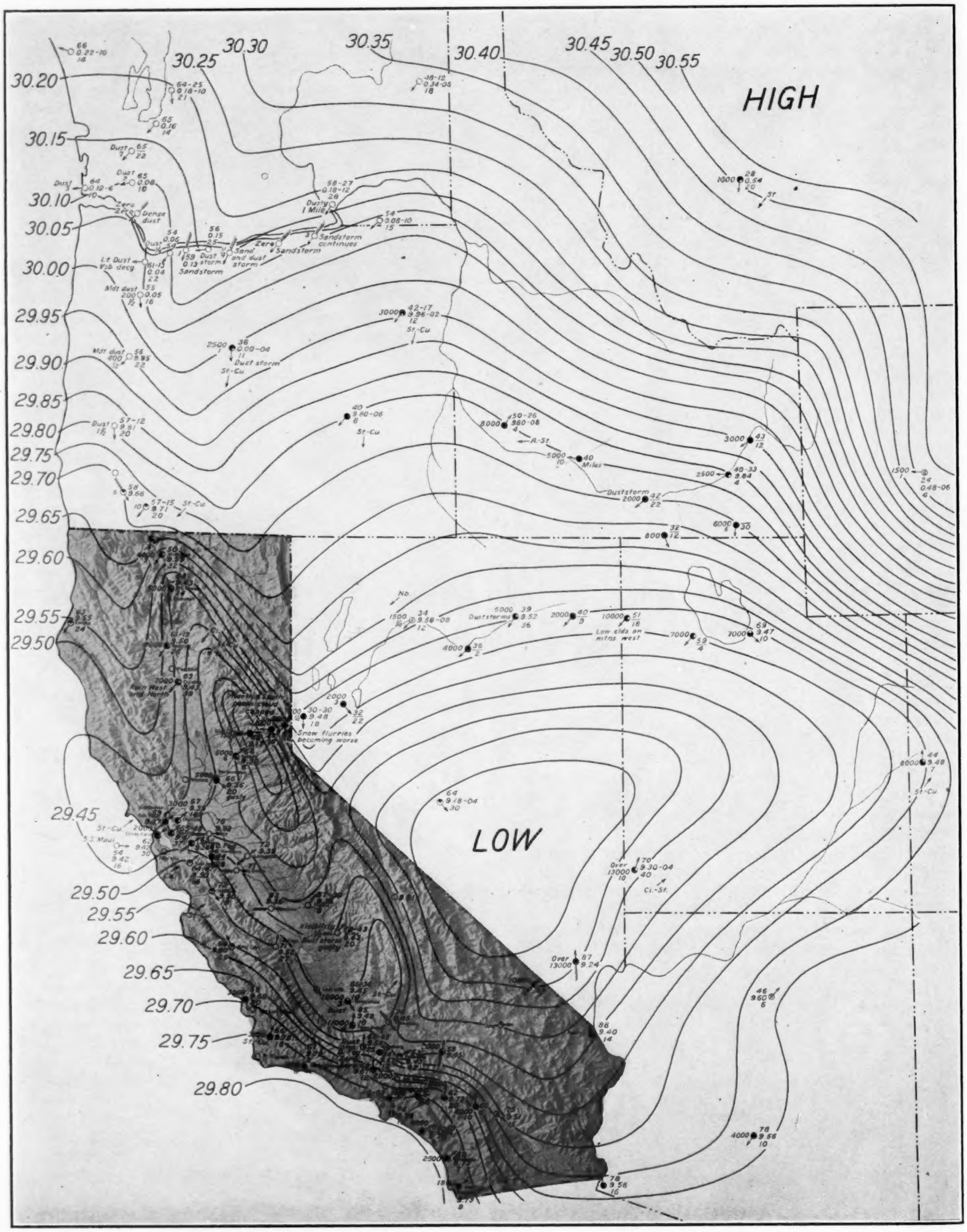


FIGURE 5.—Weather map 2 p. m. (P. S. T.) April 22, 1931. See also this REVIEW May, 1931, pp. 195–197

range being roughly similar to the upper surface of an airfoil.

To illustrate the phenomenon described, a map is presented (see fig. 5), on which all of the data from the airways weather reports are used. Isobars are drawn for each 0.05 inch of pressure to bring out the gradients. The map is of an unusual storm in which northeasterly gales prevailed over Washington, Idaho, northern Nevada, and northern California on the afternoon of April 22, 1931.[3] The barometer reading reduced to sea level at Blue Canyon on the west or leeward side of the Sierra Nevada, was 29.17 inches at 2 p. m., while the reading at Sacramento was 29.36, and at Reno 29.48. When the Blue Canyon barometer was falling steadily, the writer sent five messages over the airways teletype system to verify the accuracy of readings. Later he personally talked to the observer and examined the original record of hourly observations. All readings made during the day are considered accurate. No instrumental error, or error in method of reduction to sea level, is apparent, as the reduced readings, for Blue Canyon a day or more later returned slowly to their normal values, as shown by the mercurial barometer readings for Sacramento and Reno, but only after the northeasterly upper air winds ceased. The area of low barometer on the leeward side of the mountain barrier was caused, no doubt, by the effect of northeast gales on crossing the Sierra Nevada.

Dust and sandstorms from northeasterly gales were very bad in Washington, Oregon, and northern California on that afternoon, and the following day the S. S. *Maui* reported a heavy dust storm at sea approximately 500 miles west-southwest of the Golden Gate. This rather extraneous statement will assist the reader in identifying the day on which this meteorological situation prevailed.

[3] Cf. Cameron, Donald C., great dust storm in Washington and Oregon April 21-24, 1931. This Review 59: 195-97.

There is still another interesting phenomenon observed in many of the Lebec runs which is indicated on the Lebec northwest wind resultant curve when it is compared with those of Fresno and Los Angeles. It should be kept in mind that the balloon runs used to compute the three resultant graphs were selected from as nearly simultaneous observations as possible. It will be noted that the resultant velocity at 11,000 feet above sea level at Lebec s approximately one-third less than at the same elevation over Fresno and Los Angeles. In several individual cases when the winds over Lebec were northwesterly, a light

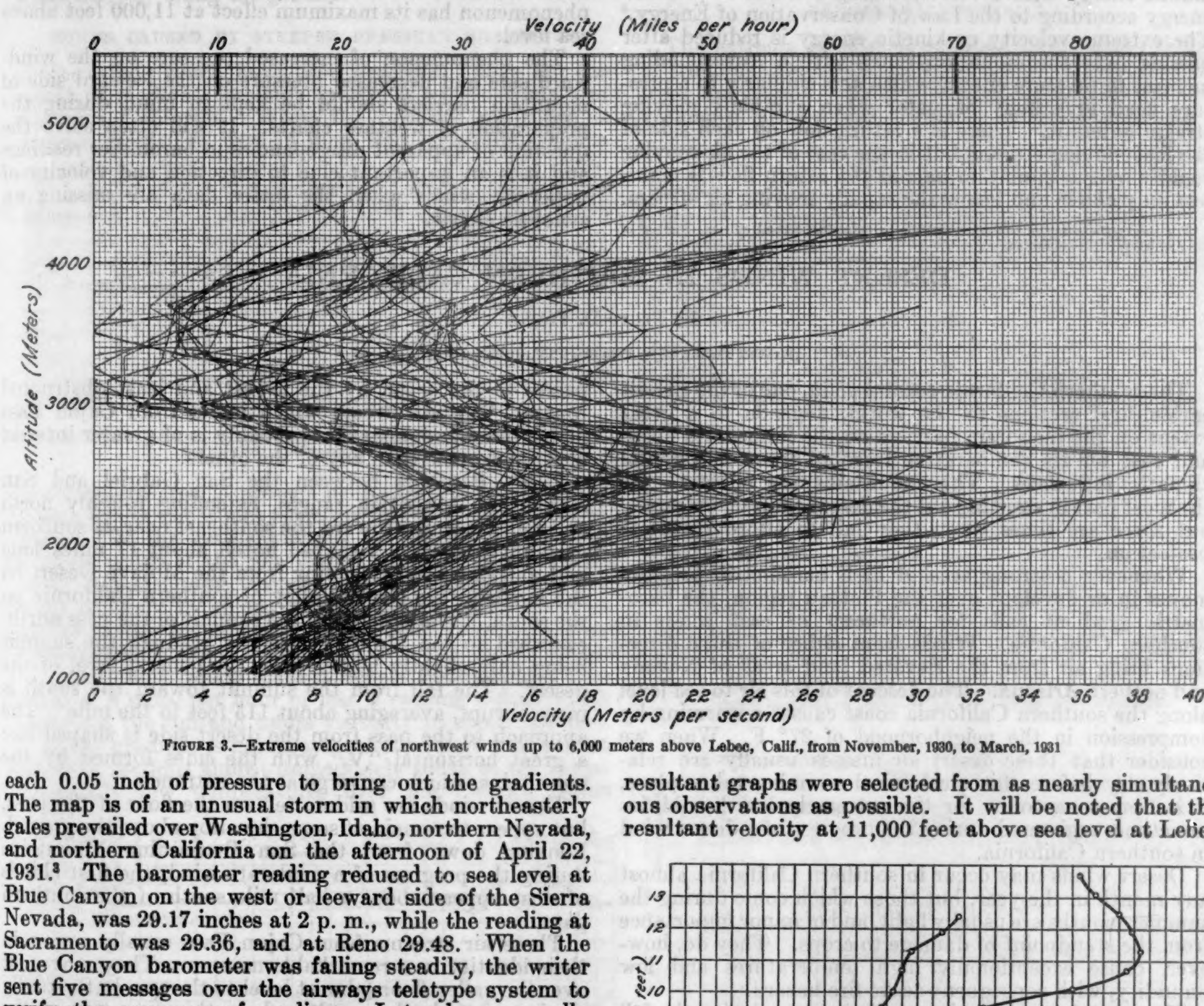


FIGURE 3.—Extreme velocities of northwest winds up to 6,000 meters above Lebec, Calif., from November, 1930, to March, 1931

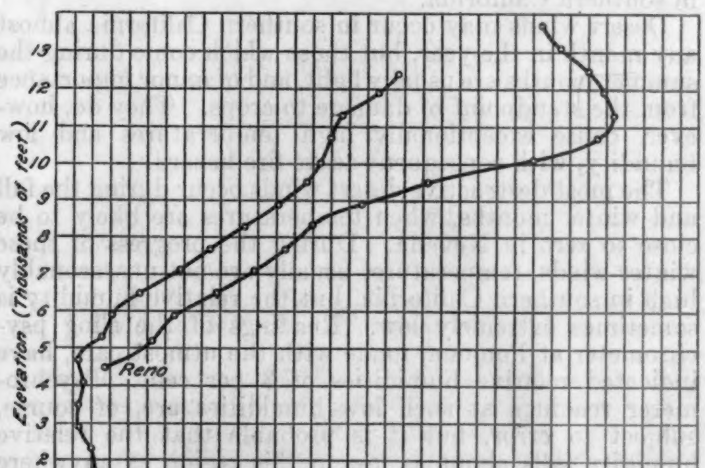


FIGURE 4.—Resultant velocities of west and southwest winds over Reno, Nev., and Fresno, Calif., during the period November, 1930, to April, 1930, inclusive. Resultants computed from 45 runs at Reno and 36 at Fresno most of which were made approximately simultaneously and the data are nearly complete to high levels

southeasterly wind has been noted at 11,000 feet above sea level with northwesterly gales below and aloft. An explanation of this phenomenon is offered herewith. The extreme velocity at 8,000 feet represents an increase in kinetic energy with a corresponding decrease in pressure energy according to the Law of Conservation of Energy.[4] The extreme velocity or kinetic energy is reduced after passing over the mountain range with a corresponding increase in pressure energy which acts similarly to a pressure head in a body of water when a rapidly moving stream enters it. There is a return flow on each side of the fast-moving stream, but in the case of the air moving rapidly over a mountain barrier the return flow is manifest only above and below the rapidly moving air stream. The return flow near the surface on the leeward side of a mountain barrier has often been noted. The return flow aloft is superimposed upon the velocity of the air mass moving over the mountain barrier which corresponds to a marked decrease in velocity. In the case of Lebec, the phenomenon has its maximum effect at 11,000 feet above sea level.

The phenomenon of increased pressure on the windward side and decreased pressure on the leeward side of mountain barriers should be kept in mind during the preparation of weather charts. It will often solve the question of apparent discrepancies in barometer readings and it is an important clue to direction and velocity of upper air winds when the latter data are missing on synoptic charts.

[4] For the mathematics of this phenomenon see page 206, second edition, Physics of the Air, by W. J. Humphreys.

DESERT WINDS IN SOUTHERN CALIFORNIA

By Floyd D. Young

[Weather Bureau office, Pomona, Calif., July 20, 1931]

The southern California coastal plain, one of the richest agricultural sections in the world, depends to a great extent on the mountain barriers on the immediate north and east for its comparative freedom from continental climatic influences. The mountains are effective for the most part in shutting out the desert climatic extremes, but there are times when they fail to afford complete protection.

Whenever a strong area of high barometric pressure moves in or develops over the Plateau region, the barometric gradient calls for northeast or east winds in southern California. Winds from either of these directions bring air from the elevated land areas of Nevada and nothern Arizona. The descent of this air to sea level along the southern California coast causes a warming by compression in the neighborhood of 27° F. When we consider that these desert air masses usually are relatively dry before this mechanical warming takes place, it is easy to account for the extremely low humidities sometimes registered during the progress of a desert wind in southern California.

Desert winds may occur in southern California almost any month in the year, but those which come during the summer months are usually light, and of minor importance from the standpoint of damage to crops. They do, however, cause exceptionally high temperatures and low humidity, with consequent acute fire hazard.

The most destructive desert winds occur during the fall and winter months, when temperatures are likely to be close to zero in Nevada. During the progress of these winter winds, temperatures usually are not unseasonably high in southern California, but the relative humidity is sometimes extremely low. Readings of the sling psychrometer at Pomona, made with the utmost care, have indicated relative humidities of 3 per cent. Psychrometer readings at such low humidities are, of course, subject to error, but it is probable that the relative humidity falls about as low in this region as anywhere in the world.

The air moving outward from the Plateau high-pressure area is blocked on the south by the San Gabriel and San Bernardino Mountains. Wherever there is a break in these southern chains, such as Cajon Pass, the desert air streams through it and out onto the Great Valley of southern California. If the pressure difference between Neavada and southern California is only moderate (0.16 to 0.40 inch) the desert winds usually are confined to rather narrow belts extending from the mouths of the passes to the ocean by the lowest and least obstructed routes. The air stream which issues from Cajon Pass under these circumstances probably is of greater interest and importance than any of the others.

Cajon Pass lies between the San Gabriel and San Bernardino Mountain ranges, extending roughly north and south, turning toward the southeast near its southern extremity. It is a V-shaped notch about 17 miles long and quite narrow, extending from the Mojave Desert on the north to the Great Valley of southern California on the south. The slope from the summit of the pass northeastward to the Mojave Desert is gradual, the summit being only slightly higher than the general level of the desert. The fall from the summit toward the south is more abrupt, averaging about 115 feet to the mile. The approach to the pass from the desert side is shaped like a great horizontal "V," with the sides formed by the mountains, which converge at the entrance.

Desert winds are seldom felt on the floor of the pass, but appear to remain at some elevation above the ground. Looking down from the San Bernardino Mountains during the progress of a moderate wind, the first clouds of dust appear about a half mile south of the southern gate.

These air streams from Cajon Pass usually maintain their identity in a remarkable manner. They move out over the valley floor (almost level to the eye, but actually sloping towards the south and west), swing toward the southwest, and either follow the canyon of the Santa Ana River through the Santa Ana Mountains or move directly over the low mountains south of the canyon and then follow a well-defined path over the almost level plains of Orange County and reach the ocean in the vicinity of Newport. On going eastward in the open country some 7 miles south of Cajon Pass, with light to gentle variable winds, one often passes abruptly into an air stream moving from the north-northeast at a velocity of 30 to 35 miles per hour. The easterly limits of the stream usually are just as well marked, and one passes from a near gale into a region of relative calm within the space of half a mile. The width of the air stream under these conditions probably will average about 5 miles. The same air current often is encountered in the perfectly open plains 15 miles or so to the southwestward, with its velocity and width substantially unchanged, and relatively calm air on either side. The stream may shift its position slightly from time to time, but appears to change but little in width or velocity. Sometimes it

spreads out somewhat after passing the Santa Ana Mountains, but usually it follows a well-defined path to the ocean. It often comes over the south foothills at the western entrance to the Santa Ana Canyon, appearing in such cases to come down the hillsides in strong gusts directly along the ground.

WINDS CAUSED BY STEEPER PRESSURE GRADIENTS

The winds which have been described above are the result of moderate pressure gradients over Nevada and southern California. When the pressure difference is greater, from 0.45 to 0.70 inch, and especially when a

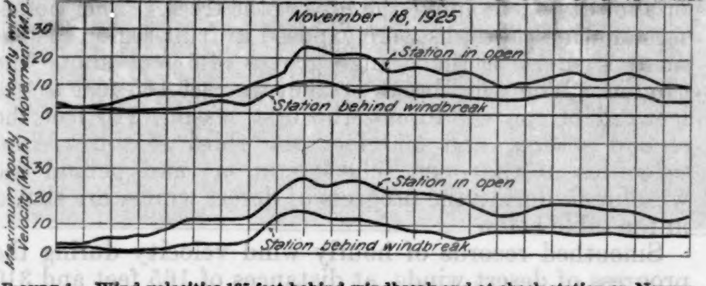


FIGURE 1.—Wind velocities 165 feet behind windbreak and at check station on November 18, 1925. (Four-cup anemometer)

low-pressure area is present over Lower California, the desert winds sometimes come directly over the mountain ranges. If the gradient winds are north, the sections directly south of the San Gabriel Mountains, which extend east and west, usually are not affected, but the wind is likely to appear at the surface about 10 miles south of the mountains. Under such conditions slow eddy currents carry heavy dust into the districts near the mountains, which make it appear locally that a west wind of 6 miles per hour or less is causing a dust which blots out the sun and limits visibility to about 500 feet.

If the gradient is northeast, strong desert winds often occur in sections almost immediately south of the range. Unusually low temperatures over the Plateau region

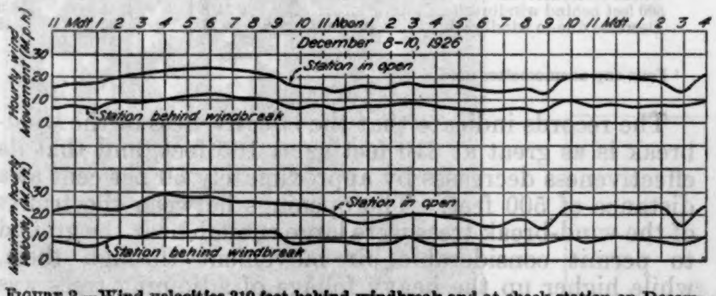


FIGURE 2.—Wind velocities 310 feet behind windbreak and at check station on December 8-10, 1926. (Four-cup anemometer)

commonly increase the severity of desert winds in southern California. When temperatures are relatively high over the Plateau, the winds blowing over the mountains normally remain at higher levels and do not reach the ground.

While these winds still cause heavy damage to citrus groves every few years, there is no doubt that the same pressure gradients produce surface winds of considerably less severity now than they did in the days when southern California was given over almost entirely to grazing. Windbreaks, orchard and shade trees, and buildings have moderated the fury of the gales which occurred in earlier times. Pioneer citrus growers tell of the terrific force of the desert winds of 50 years ago, of the unroofing of houses and barns, of crawling on hands and knees from house to barn to water the stock, and of the trunks of young trees almost severed by the cutting action of flying gravel and sand.

ELECTRICAL PHENOMENA

The extreme dryness of a desert wind causes charges of frictional electricity to build up on objects insulated from the ground. Heavy charges develop on the body varnish of automobiles, and when the driver reaches to

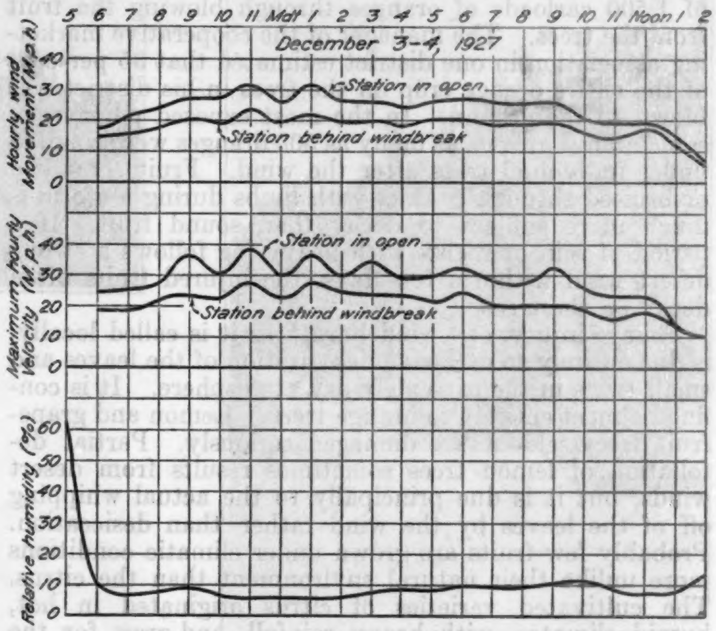


FIGURE 3.—Wind velocities 500 feet behind windbreak and at check station, and hourly relative humidity on December 3-4, 1927. (Four-cup anemometer)

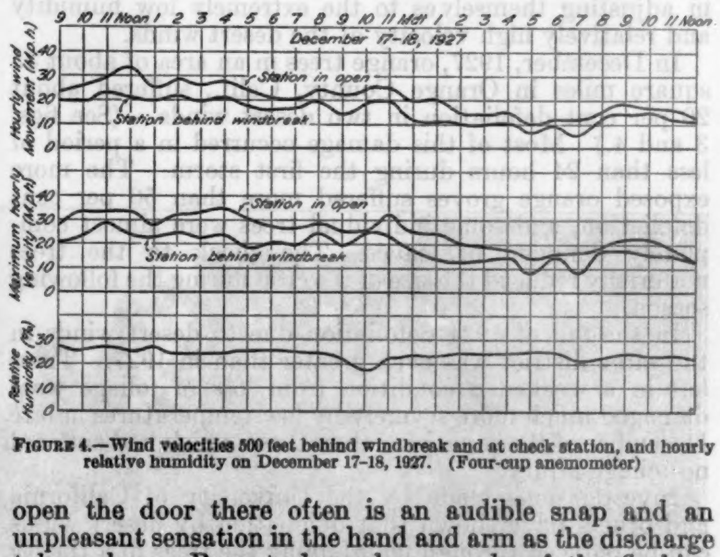


FIGURE 4.—Wind velocities 500 feet behind windbreak and at check station, and hourly relative humidity on December 17-18, 1927. (Four-cup anemometer)

open the door there often is an audible snap and an unpleasant sensation in the hand and arm as the discharge takes place. Reports have been made of the flashing luminosity of large pieces of bounding gravel carried by the wind at night, whenever they touched the ground. These electrical manifestations which are an accompaniment of desert winds with extremely low humidity, are erroneously believed by a large proportion of southern California residents to be the principal cause of damage to vegetation. In many sections the winds are known almost exclusively as "electrical storms."

DAMAGE TO CROPS

Damage to crops, especially citrus fruits, due to desert winds, is sometimes enormous. Citrus damage is of two kinds, the mechanical injury to the trees and fruits owing to the high velocity of the wind, and the desiccating effects of the extremely dry air on the foliage. When the wind velocity is high, 30 to 40 miles per hour, much fruit is blown to the ground and a great deal of that left on the trees is badly scarred through limb rubbing. Two desert winds which occurred in Orange County, Calif., during December, 1927, caused an estimated loss of 1,500 carloads of oranges through blowing the fruit from the trees. The manager of the cooperative marketing association in one district estimated that 35 per cent of the entire orange crop on the trees in his district was blown to the ground. In the most exposed portions of some orange groves, as many as 500 oranges were counted under individual trees after the wind. Fruit scratched or bruised through contact with limbs during a storm is much more subject to decay than sound fruit. If a period of rain or nights with heavy fog follows a strong desert wind within a few days, the injured fruits often decay on the trees.

Foliage injury, or "wind burn," as it is called locally, is due entirely to excessive dehydration of the leaves and small twigs in the extremely dry atmosphere. It is confined almost entirely to orange trees. Lemon and grapefruit trees seldom are damaged seriously. Partial defoliation of lemon trees sometimes results from desert winds, but it is due principally to the actual whipping off of the leaves by the wind rather than desiccation. Probably few fruits are grown under climatic conditions more unlike their natural environment than the citrus. The cultivated varieties of citrus originated in hot, humid climates, with heavy rainfall, and grew for the most part under partial shade.

It is not surprising, therefore, that they have difficulty in adjusting themselves to the extremely low humidity and relatively high velocity of the desert winds.

In December, 1927, orange trees in an area of about 35 square miles in Orange County, Calif., suffered about 20 per cent defoliation in two desert winds. (See figs. 3 and 4.) Most of this damage occurred in a period of less than 24 hours during the first storm. The more exposed orange groves suffered more than 50 per cent defoliation, and some individual trees were almost completely denuded of leaves. The shock to the trees materially reduced the size of the crop during the following season.

In the fall of 1924 defoliation due to desert winds in the same district was even greater than in 1927. Trees left in a weakened condition from loss of foliage were damaged much more severely by low temperatures in late December of the same year than those which had suffered no foliage injury.

Investigations made by the University of California and others have shown that defoliation by desert winds can be reduced through maintaining the trees in a thrifty condition and developing vigorous root systems, and by having adequate supply of moisture available to the trees immediately prior to the onset of the wind.

EFFECTIVENESS OF WIND BREAKS

Following the damaging desert winds in the fall of 1924, a study of the effect of windbreaks on the wind velocity and relative humidity was undertaken by the fruit-frost service of the Weather Bureau, in cooperation with the Villa Park Orchards Association and the Orange County Fruit Exchange. Records of wind velocity, relative humidity, and temperature were obtained at two stations in a citrus district subject to desert winds, one in an area without windbreaks and the other at varying distances behind a windbreak about a mile to the westward in the same general location. The windbreak was 1,280 feet long and extended north and south. Approximately one-half its length was made up of eucalyptus (blue gum) trees, about 95 feet high, and one-half Montrrey cypress, about 70 feet high. (See fig. 5.) The windbreak trees were 30 years old. The orange trees, set 24 feet apart on the square, were 28 years old. Anemometers at both stations were placed 18 feet above the ground, or about two feet above the tops of the trees. Thermometers and hydrographs were exposed in fruit-region instrument shelters in the orange groves, 4.5 feet above the ground. The wind-break station was set 165 feet to the leeward of the windbreak the first season, 310 feet the second season, and 500 feet the third season. Wind velocities in the open (check station) and behind the windbreak during the progress of desert winds, are shown in the table below.

Smoothed records of hourly wind velocity during the progress of desert winds, at distances of 165 feet and 310 feet, respectively, behind the windbreak, and at the check station, are shown in Figures 1 and 2.

	Average hourly wind velocity [1]	Average hourly maximum velocity (5 minutes)[1]	Maximum velocity period of wind[1]
Nov. 18, 1925:			
Check station	12.0	15.0	27.0
165 feet behind windbreak	5.5	6.5	15.0
Decrease due to windbreak ... per cent	54	57	44
Dec. 8-10, 1926:			
Check station	18.0	22.0	29.0
310 feet behind windbreak	8.0	9.0	13.0
Decrease due to windbreak ... per cent	56	59	55
Dec. 3-4, 1927:			
Check station	23.1	27.6	38.0
500 feet behind windbreak	17.3	20.3	27.0
Decrease due to windbreak ... per cent	25	26	29
Dec. 17-18, 1927:			
Check station	20.4	25.7	34.0
500 feet behind windbreak	14.8	18.1	28.0
Decrease due to windbreak ... per cent	27	30	18

[1] Four-cup anemometers used.

The records indicate that the effectiveness of the windbreak is as great at 310 feet as at 165 feet, and that its effectiveness decreases by approximately 50 per cent at a distance of 500 feet. The openings between the trunks of the wind-break trees were large enough near the ground to permit considerable air movement through them, while higher up the heavy foliage of adjoining trees was interlaced, leaving few open spaces. It is believed that the wind entering the orchard near the ground increased the velocities shown at the 165-foot station and accounted for the lack of difference between the velocities at 165 feet and 310 feet. This breeze coming in between the tree trunks very close to the ground undoubtedly was spread and dissipated to a large extent by the resistance of the orange trees before it had traveled far into the orchard.

The two winds which occurred in December, 1927, noted in the table, caused considerably more damage to citrus trees and fruits than any others experienced during the time the wind-break study was carried on. Smoothed records of hourly wind movement and maximum hourly velocity at the check station and the station 500 feet behind the windbreak are shown in Figures 3

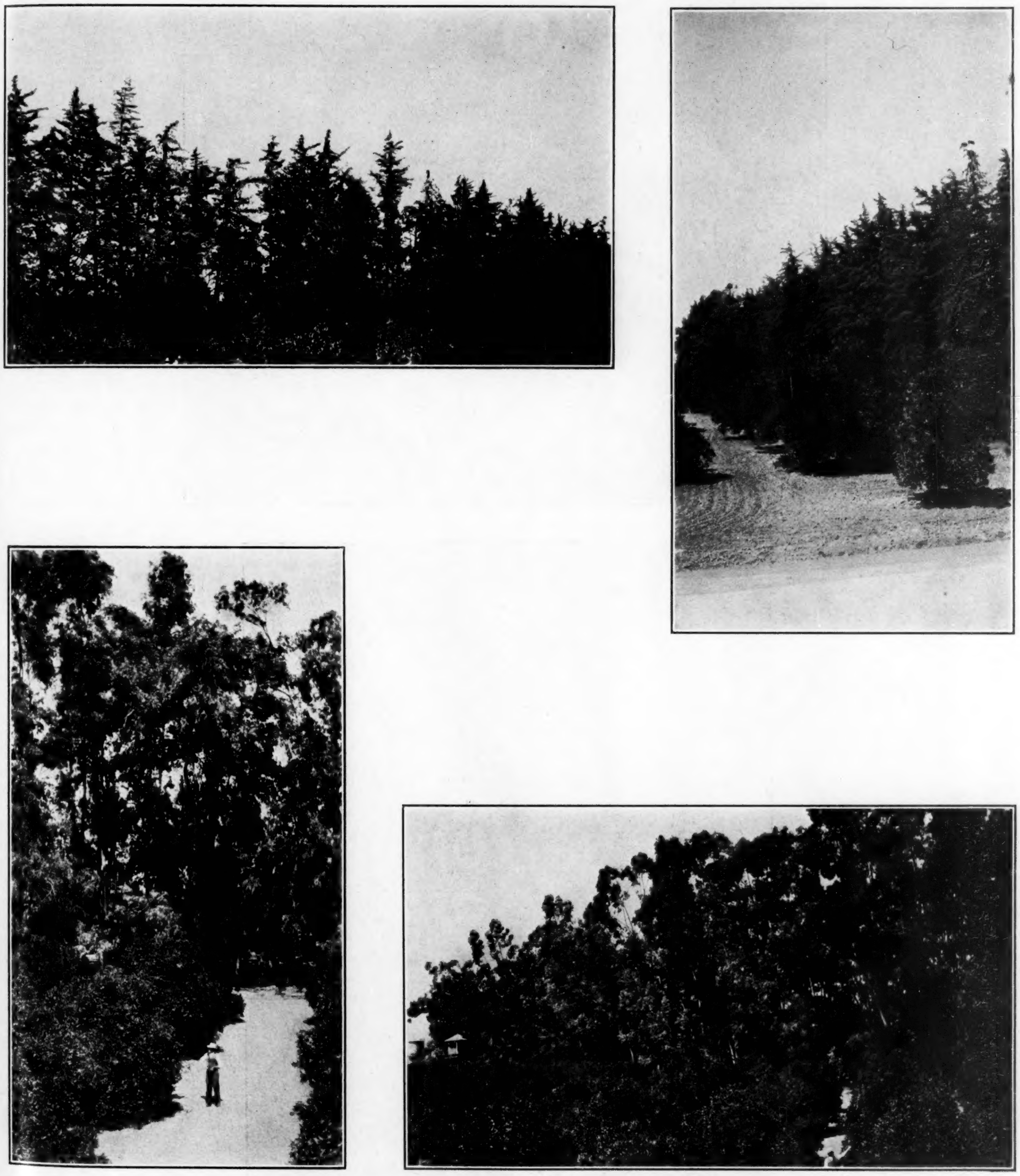
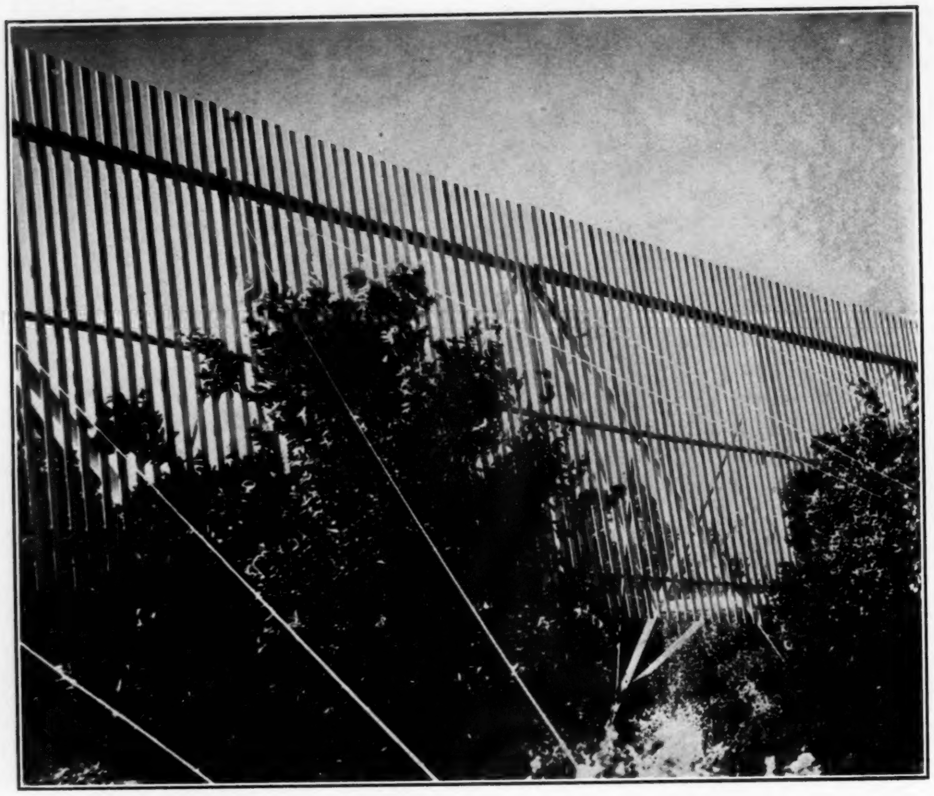


FIGURE 5.—Views of Eucalyptus and Cypress windbreak used in experiment



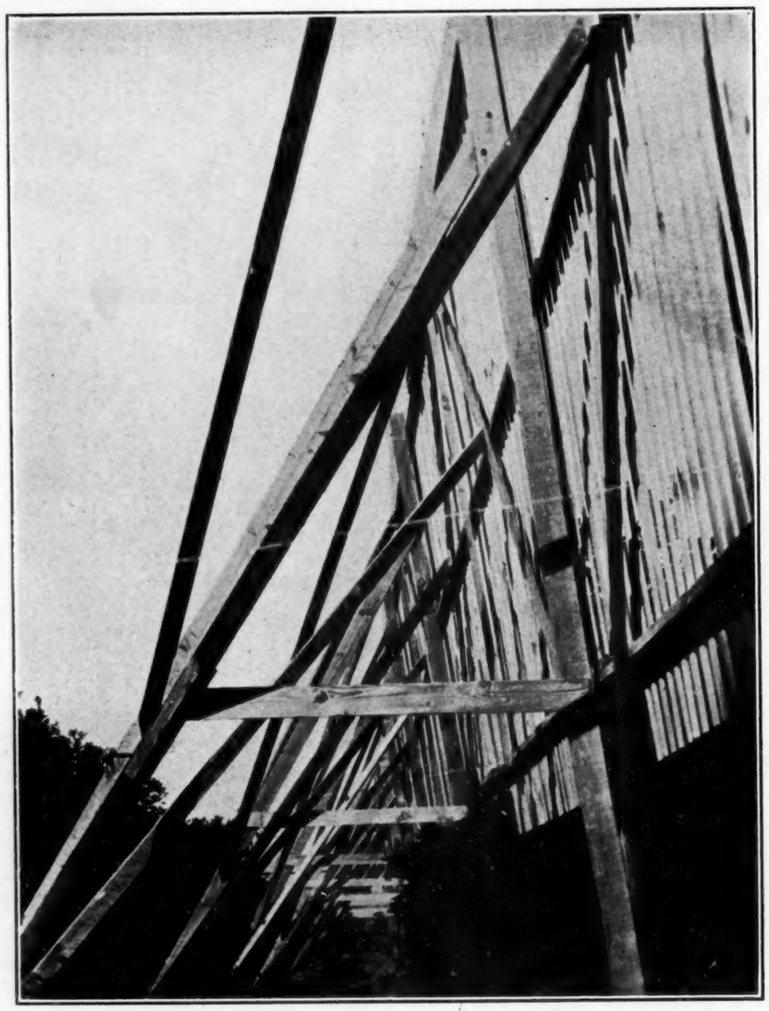


FIGURE 6.—Views of artificial windbreak 28 feet high in orange grove near El Modena, Calif. Many different types of artificial windbreaks have been developed, but none has been very successful in protecting mature citrus trees. Photos by H. A. Rathbone

and 4. Smoothed records of hourly relative humidity, taken from a carefully checked and regulated hair hygrograph, are included.

The records obtained during these two wind storms as well as the records of many lighter and less destructive desert winds, indicate quite definitely that "wind burning" of citrus trees occurs only when the relative humidity is unusually low. Heavy winds without excessively low relative humidity have caused no burning whatever, while relatively light winds with low humidity have never failed to cause some damage to foliage. While the dividing point on the relative humidity scale between burning and no burning varies slightly with different wind velocities and different conditions of the trees, all the records obtained in this study indicate that foliage burn is suffered only when the relative humidity falls to 10 per cent or lower. So far as could be determined, all the foliage burn which occurred during December, 1927, was caused by the first desert wind, on the 3d and 4th. The second wind, on the 17th and 18th, blew off many leaves which had been damaged in the earlier storm, but apparently caused no new burning. The second wind blew considerably more fruit from the trees than the first one, but this was owing to the fact that the loss of foliage during the first wind left the fruit on the inside of the trees without protection.

A careful inspection of the two orange groves in which the wind-break studies were carried on was made immediately after the desert winds of December, 1927. At the check station the average loss of foliage caused by "wind burning" was 30 per cent over the entire orchard. In the orchard behind the windbreak there were very slight indications of burning in the tops of the trees for a distance of 72 feet therefrom, probably caused by the wind which came through the lower part of the break. Soil moisture condition, due to the proximity of the wind-break trees, also probably was a factor. From 72 feet to 288 feet from the break there was no burning whatever. From 288 feet to 500 feet the amount of burn slowly increased from zero to about 2 per cent. From 500 feet to the western boundary of the orchard, 784 feet from the break, the damage increased more rapidly, the heaviest burn appearing in the last 250 feet. In the last row the foliage burn was estimated to be approximately 10 per cent.

In the orchard protected by the windbreak no fruit was blow off the trees for a distance of 288 feet. From this point to the 500-foot line fruits on the ground averaged four to the tree. From 500 feet to the western border of the orchard, 784 feet from the windbreak, the number of fruits per tree on the ground increased rapidly. A count of oranges under 10 trees in the last row showed an average of 30 per tree.

The number of oranges per tree on the ground in the check orchard varied from 98 to 452, with an average for all parts of the grove of 163.

The relative humidity was always somewhat higher behind the windbreak during relatively light desert winds, but there was little difference between the two stations during the heaviest winds.

These studies indicate that a windbreak such as the one for the orchard in which the records were obtained, affords practically complete protection from desert winds, both as to loss of fruit and damage to foliage, up to a distance of about 500 feet, and partial protection up to at least 800 feet from the break. Data on wind damage show the necessity for an adequate system of windbreaks throughout the sections visited most frequently by desert winds. The disastrous effects of desert winds in 1924 and 1927 resulted in the planting of many miles of new windbreaks in portions of Orange County, but lack of severe winds in recent years has resulted in many of them being removed. Large windbreak trees compete for food and moisture with citrus trees in adjoining rows, and cause some reduction in the crop of fruit. Also the planting of windbreaks throughout a large area increases the frost hazard to some extent. However, the protection from desert wind damage far outweight either of these factors in the districts most subject to wind damage.

Many different types of windbreaks have been devised in addition to the familiar lines of growing trees. Views of artificial windbreaks erected in an orange grove near El Modena, Calif., are shown in Figure 6. They are placed in every fourth tree row north and south, or about 96 feet apart, extend to a height of about 23 feet and are anchored firmly to heavy stakes driven into the ground. Their cost, when constructed with secondhand lumber, was slightly more than 75 cents per running foot.

Studies to determine the effectiveness of these windbreaks were carried on during the winter of 1930–31. Unfortunately the wind direction at the chosen location was subject to change from north to east, or vice versa, during the progress of desert winds, so that the wind direction was sometimes parallel to the windbreaks. When the wind was in the east its velocity midway between two breaks was reduced by approximately 50 per cent, but when the wind direction changed to north, the velocity was sometimes stronger between the breaks than at the check station. The windbreak structures withstood velocities as high as 20 miles per hour without any indication of weakness.

Acknowledgment is due Mr. Harold A. Rathbone, junior meteorologist in the Weather Bureau, for installing and caring for meteorological equipment at the two wind stations, and for keeping records of wind damage. The writer is grateful for his assistance.

SNOW COVER IN SOUTHERN CANADA AS RELATED TO TEMPERATURES IN THE NORTH ATLANTIC STATES AND THE LAKE REGION

By R. H. WEIGHTMAN

[Weather Bureau, Washington, D. C., September 25, 1931]

It has been stated frequently, and apparently with reason, that a snow cover of more than normal amount over central and eastern Canada in the late winter should retard the usual rapid rise of spring temperatures in the Lake Region and the north Atlantic States, with resultant low temperatures over those regions during the spring months, particularly the month of April. Similarly snow cover greater than normal over northwestern Canada and northeastern Alaska in the late winter should be followed by low spring temperatures in the Plains States and Upper Mississippi Valley.

Amount of snowfall for the month is available at a number of stations in Canada and northeastern Alaska but the amount of snowfall during one month is not the information that will have the most direct bearing on temperatures in our northern border States in the follow-

ing month. The feature that should have the most important effect is the depth of snow at the end of the month, as for example March as affecting temperatures in April. This is true because the greater the depth of snow, the longer will the snow cover last, other conditions being equal. The snowfall might have been considerable during the month of March and yet, due to melting and evaporation all of it and some that was already on the ground at the beginning of the month might not be available at the end of the month to exercise any effect on subsequent temperatures. It is found that for stations in southern Canada, a number of which have depth of snow at the end of the month available beginning with 1916, even with a considerable fall of snow during the month of March, the depth at the end of March was less than at the end of February. For example, the depth of snow at Ottawa at the end of February, 1916, was 41.5 inches, the fall of snow during the month of March, 1916, was 23.1 inches, while at the end of March, 1916, the total depth was only 7 inches. No data for depth of snow at end of the month are available for Alaskan stations.

Our study is therefore confined to the years 1916 to 1928, a period of 13 years in all. It was decided to enter on working charts the amount of snow on the ground at the end of March for Canada and on the same base map to draw lines in the United States showing departures from normal temperatures as taken from the MONTHLY WEATHER REVIEW. It may be questioned whether the actual depth of snow would be as good an index as either departure from normal or percentage of normal. There are, however, obvious objections to one of these methods alone so that it was decided to use a combination of them, whereby the depth of snow will be indicated and, in addition, information made available to show when the snow cover was greater or less than normal. Table 1 shows depth of snow on the ground at the end of March for 30 stations, all of which, with the exception of Dawson, are in southern Canada. The location of these stations is shown on chart 1. The figures in italics are interpolated values. The average depth at the end of March appears at the foot of each column. Charts 2 to 14 show by black lines the depth of snow on the ground at the end of March in southern Canada for the 13-year period, 1916–1928, while red hatchings show areas where snow cover was greater than normal. Departures of temperatures from normal in the United States for April, as taken from the MONTHLY WEATHER REVIEW, are shown by red lines.

NORTH ATLANTIC STATES

It was decided to first compare outstanding cold and warm months in the North Atlantic States district No. 1 (see Chart No. 1), followed later with similar comparisons for the Lake region, district No. 3, and then take a few cases of the extensive cold and warm months for northern States from the eastern slope of the Rocky Mountains to New England. Districts 1, 3, 4, 5, and 7.

Let us first examine Aprils with temperatures 1° or more below normal in the North Atlantic States as represented by the means of 10 stations well distributed in New England, central and eastern Pennsylvania and eastern New York. They were 1917 (−1.5°), 1920 (−1.7°), 1926 (−3.6°), and 1928 (−1.4°). We may summarize briefly the snow cover conditions in southern Canada at the end of March for these years, as follows:

1917.—Above normal over the middle and lower St. Lawrence Valley with an area extending westward to the east of Lake Superior and to the north of Lake Huron; also, over portions of Saskatchewan, and northern Manitoba. Elsewhere, so far as observations are available, snow cover was below normal. This condition was followed by April temperatures, 1.5° below normal in the North Atlantic States.

1920.—Above normal over Manitoba, central and southern Saskatchewan, and central Alberta, but considerably below normal over eastern Canada as a whole. The April temperature departure in the North Atlantic States was −1.7°.

1926.—Above normal in the St. Lawrence Valley, southeastern Ontario, and Canadian Maritime Provinces but below normal over central and western Canada. In the North Atlantic States, April temperatures averaged 3.6° below normal.

1928.—This year was very similar as regards snow cover to that of 1926, but with a temperature deficit in April of 1.4° in the North Atlantic States.

Of the four cold Aprils, three, namely, 1917, 1926, and 1928, were preceded by a snow cover greater than normal in the St. Lawrence Valley, while the fourth case, 1920, was just the opposite, as snow cover less than normal existed in that region at the end of March. The year 1923 showed the greatest and most extensive snow cover at the end of March of any year of the series for which data are available. The region with above normal depth extended from the Canadian Maritime Provinces westward over Quebec, Ontario, central and southern Manitoba and Saskatchewan. Temperatures in the North Atlantic States were, however, only 0.4° below the normal. The next heaviest month was March, 1916, with snow cover above normal, extending over all of Ontario and northern Manitoba, being followed by April temperature departures in the North Atlantic States of only −0.2°.

The other months of March had snow cover either very close to or below the normal over the St. Lawrence Valley region, in practically all cases being followed by near or above normal April temperatures in the North Atlantic States, except in 1920, when with considerably below normal snow cover in the St. Lawrence Valley and westward over Ontario, the April temperature averaged 1.7° below normal.

We have thus far examined years in which the April temperatures in the North Atlantic States were below normal. Let us now give attention to years in which temperatures in that region were 1°, or more, above normal, as follows: 1921 (+5.6°), 1922 (+1.8°), and 1925 (+2.2°).

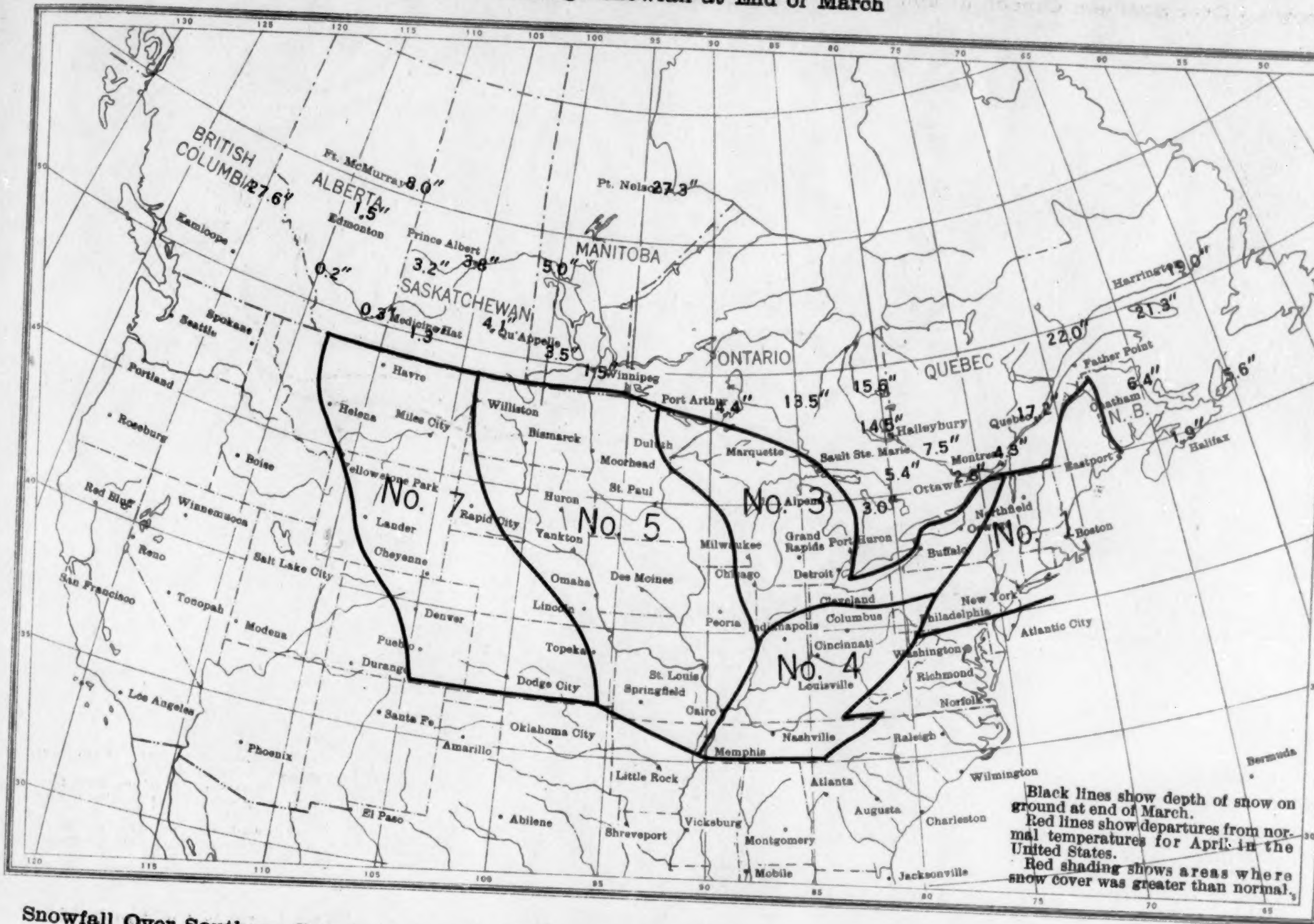
1921.—Snow cover was less than normal at the end of March over central and eastern Canada, being much below in the St. Lawrence Valley and in Ontario from Port Arthur eastward to Cochrane and Haileybury, the only area of above normal cover was over northern Saskatchewan and northern Manitoba. These conditions were followed by April temperatures in the North Atlantic States, 5.6° above normal.

1922.—Snow cover was below normal in the St. Lawrence Valley, western Ontario, and southeastern Manitoba, being followed by an April temperature departure in the North Atlantic States of +1.8.

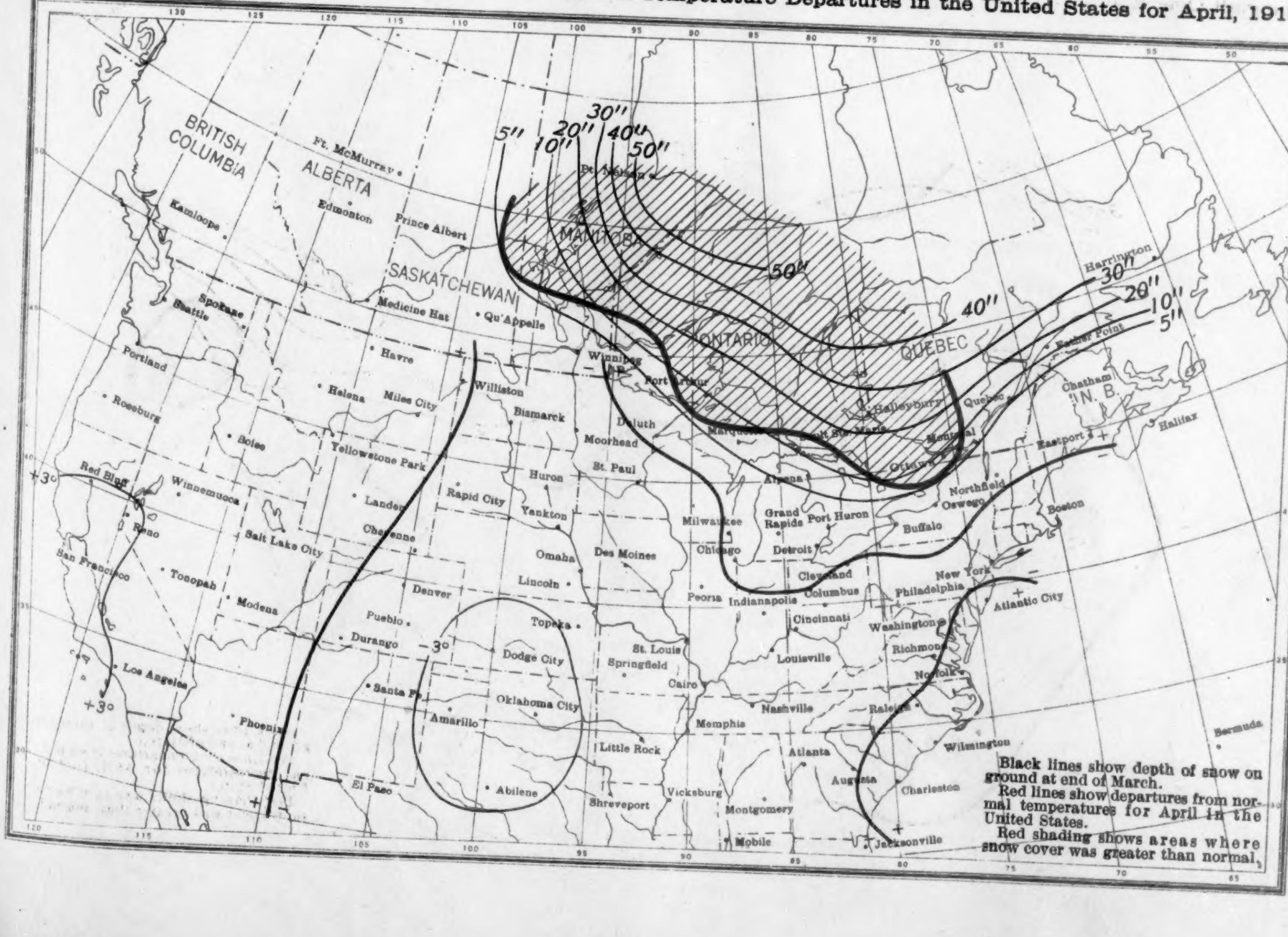
1925.—Snow cover was below normal in the St. Lawrence Valley except at Quebec, in eastern Ontario, except at Cochrane, and in Saskatchewan and Manitoba, being followed in April by temperatures 2.2° above normal in the North Atlantic States.

In all three cases of warm Aprils in the North Atlantic States, snowfall was below normal in the St. Lawrence Valley.

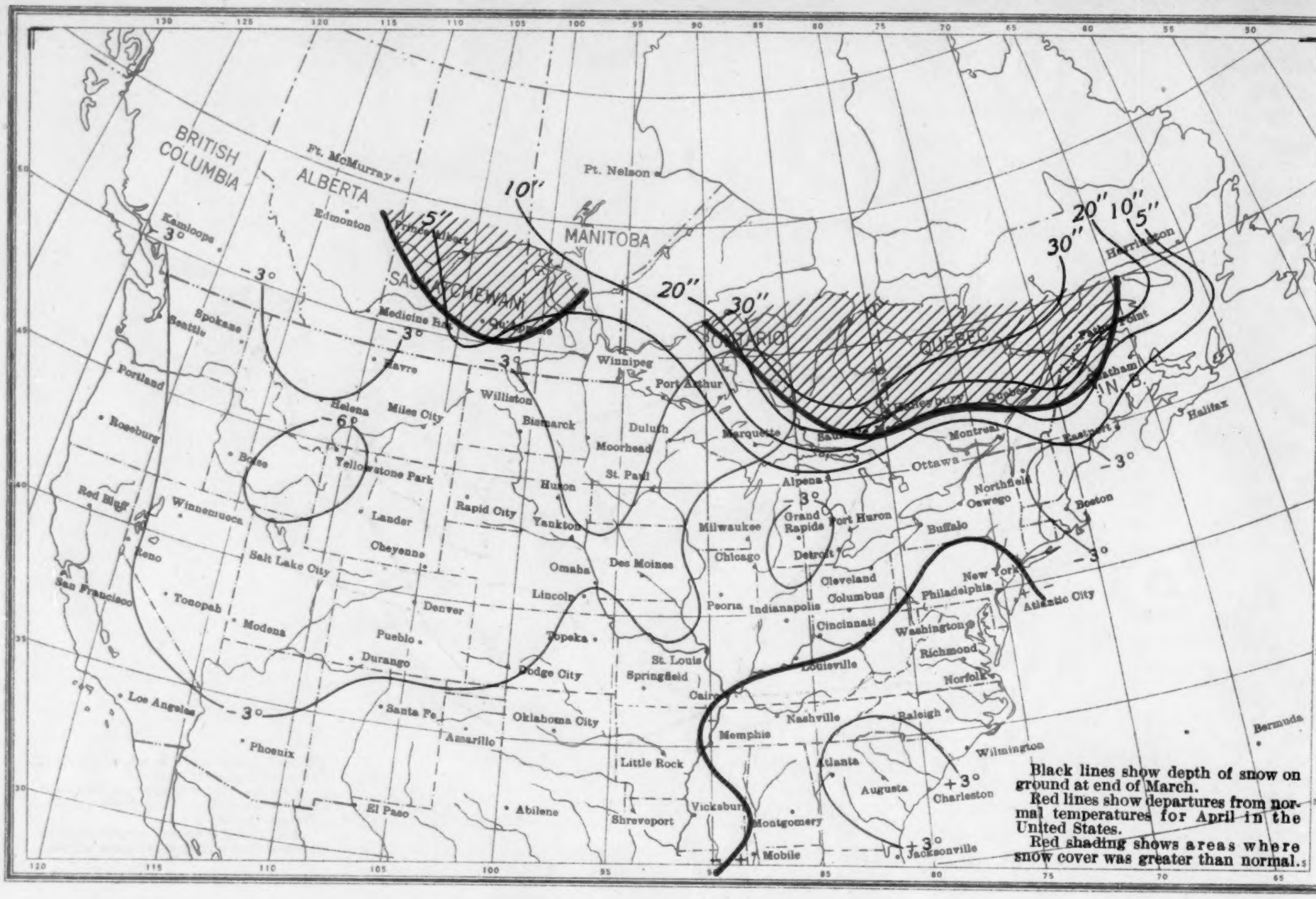
Average Snowfall at End of March



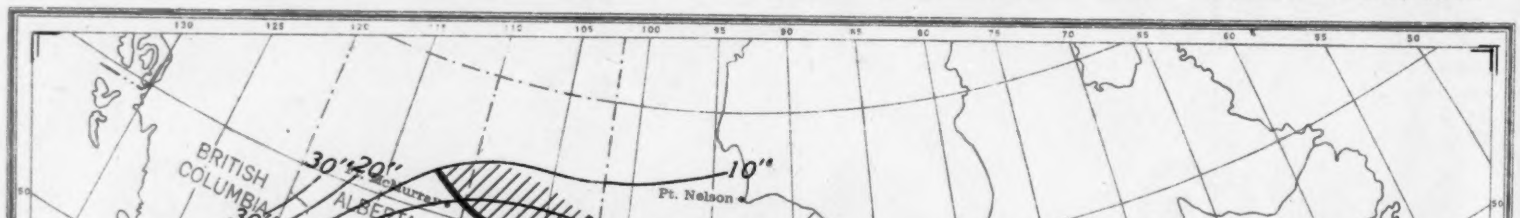
Snowfall Over Southern Canada at End of March and Temperature Departures in the United States for April, 1916



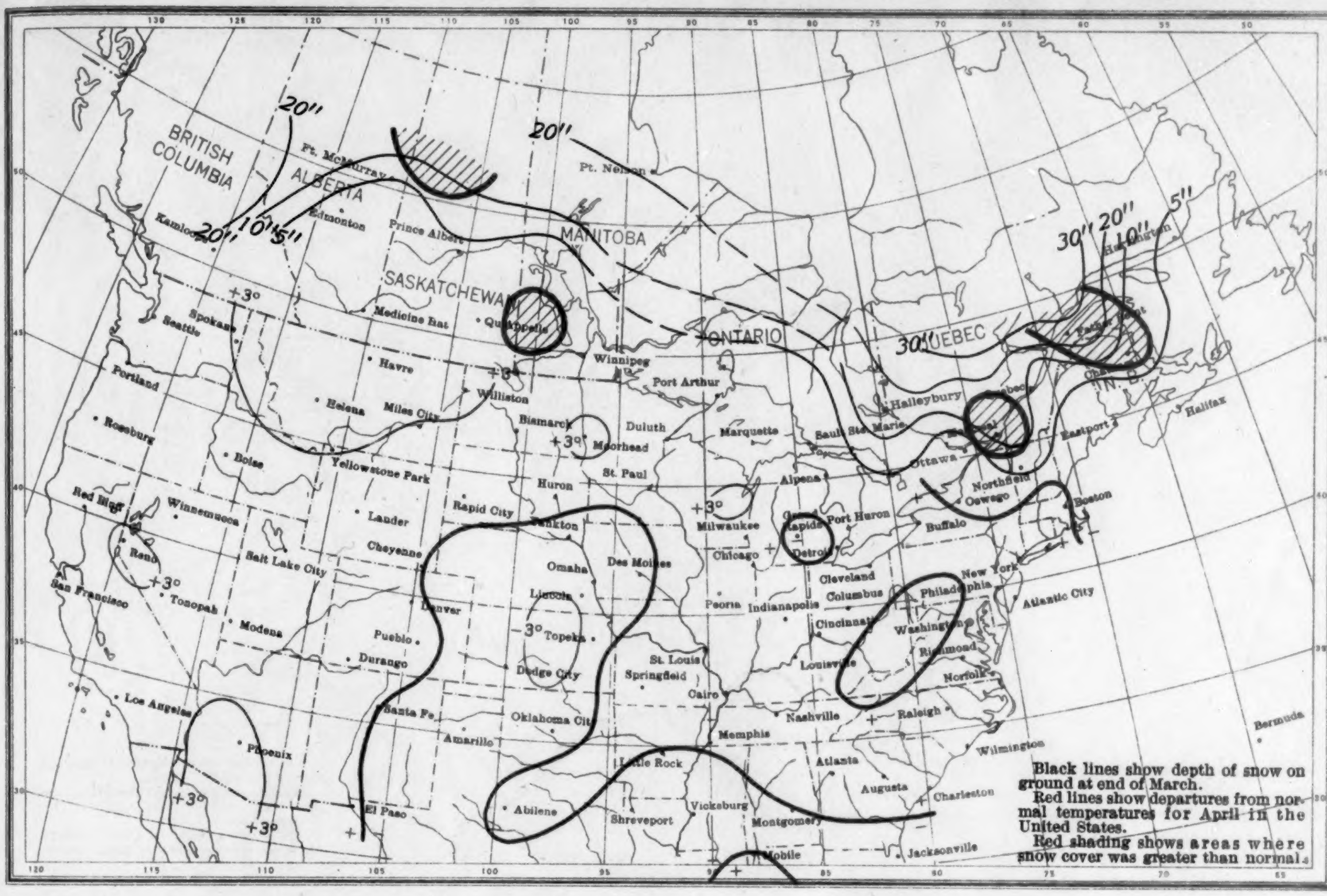
Snowfall Over Southern Canada at End of March and Temperature Departures in the United States for April, 1917



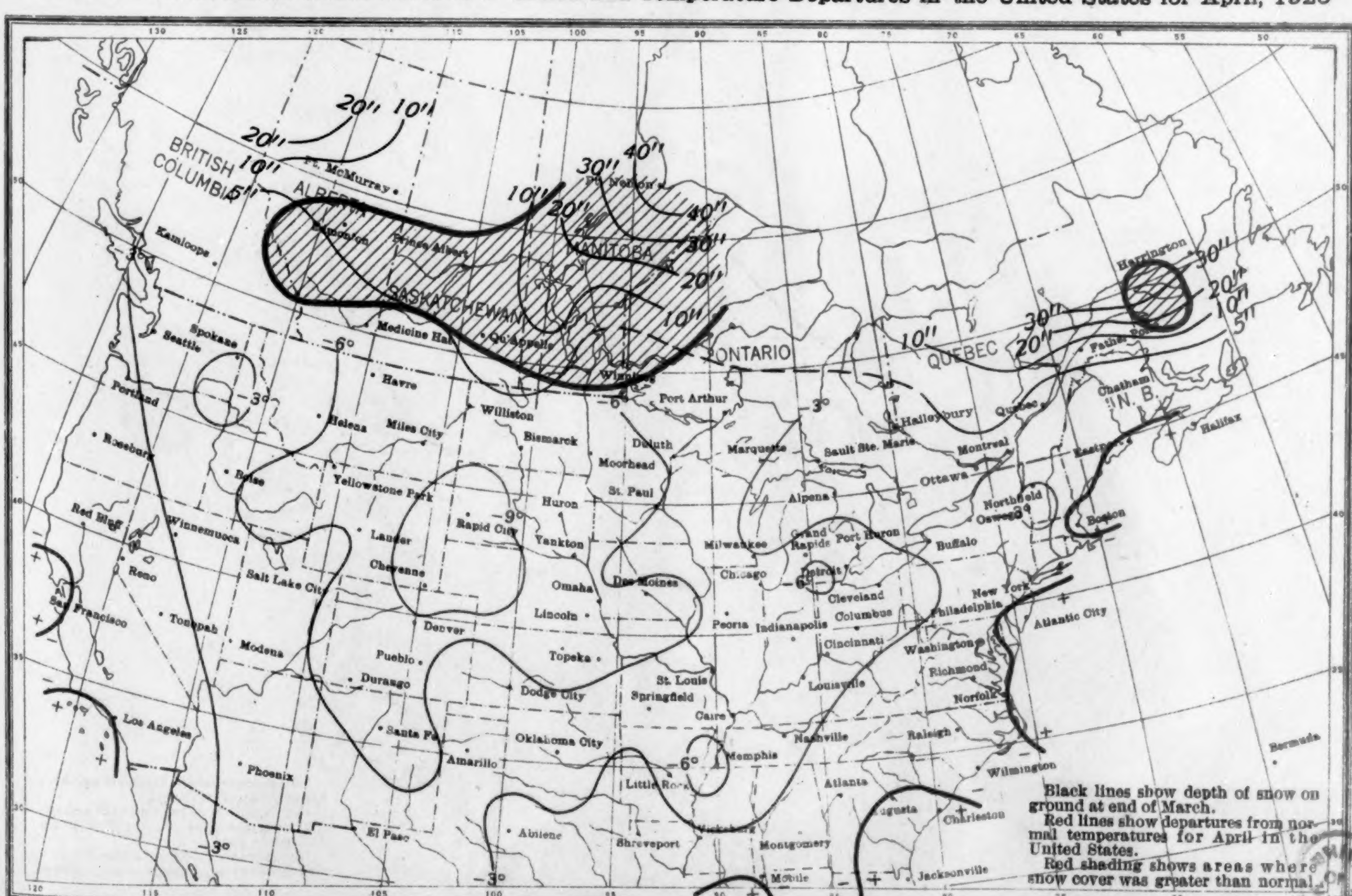
Snowfall Over Southern Canada at End of March and Temperature Departures in the United States for April, 1918



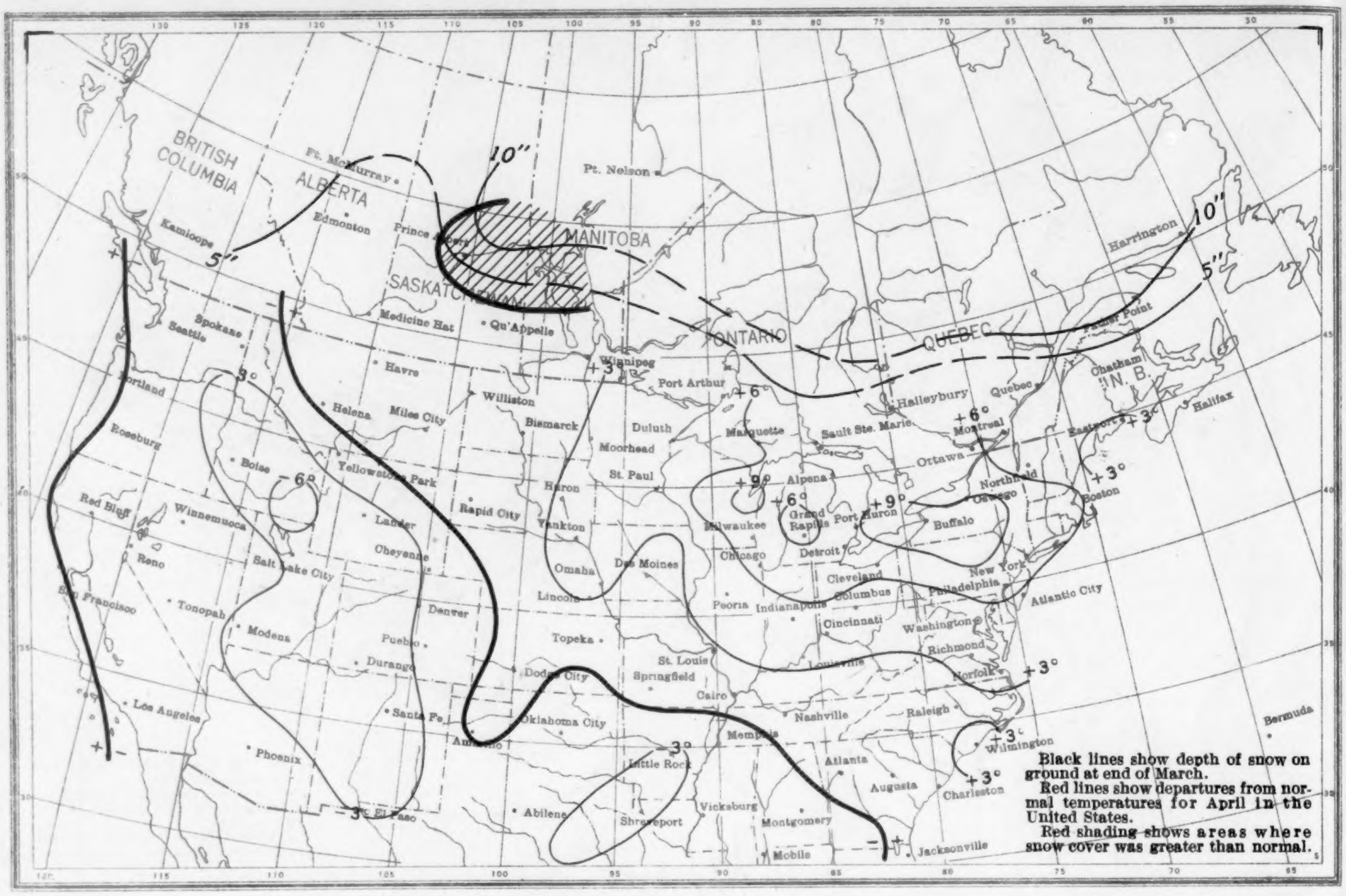
Snowfall Over Southern Canada at End of March and Temperature Departures in the United States for April, 1919



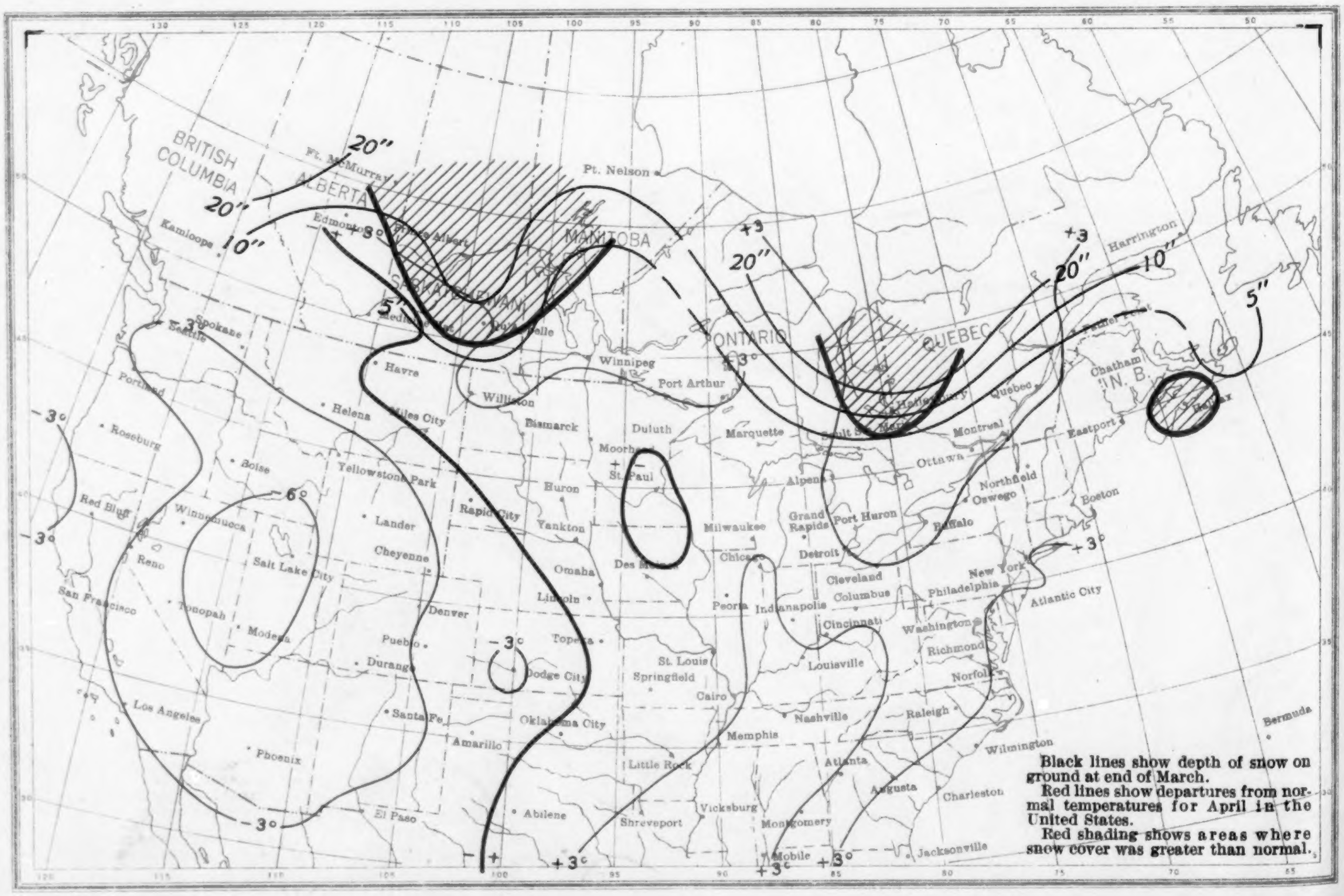
Snowfall Over Southern Canada at End of March and Temperature Departures in the United States for April, 1920



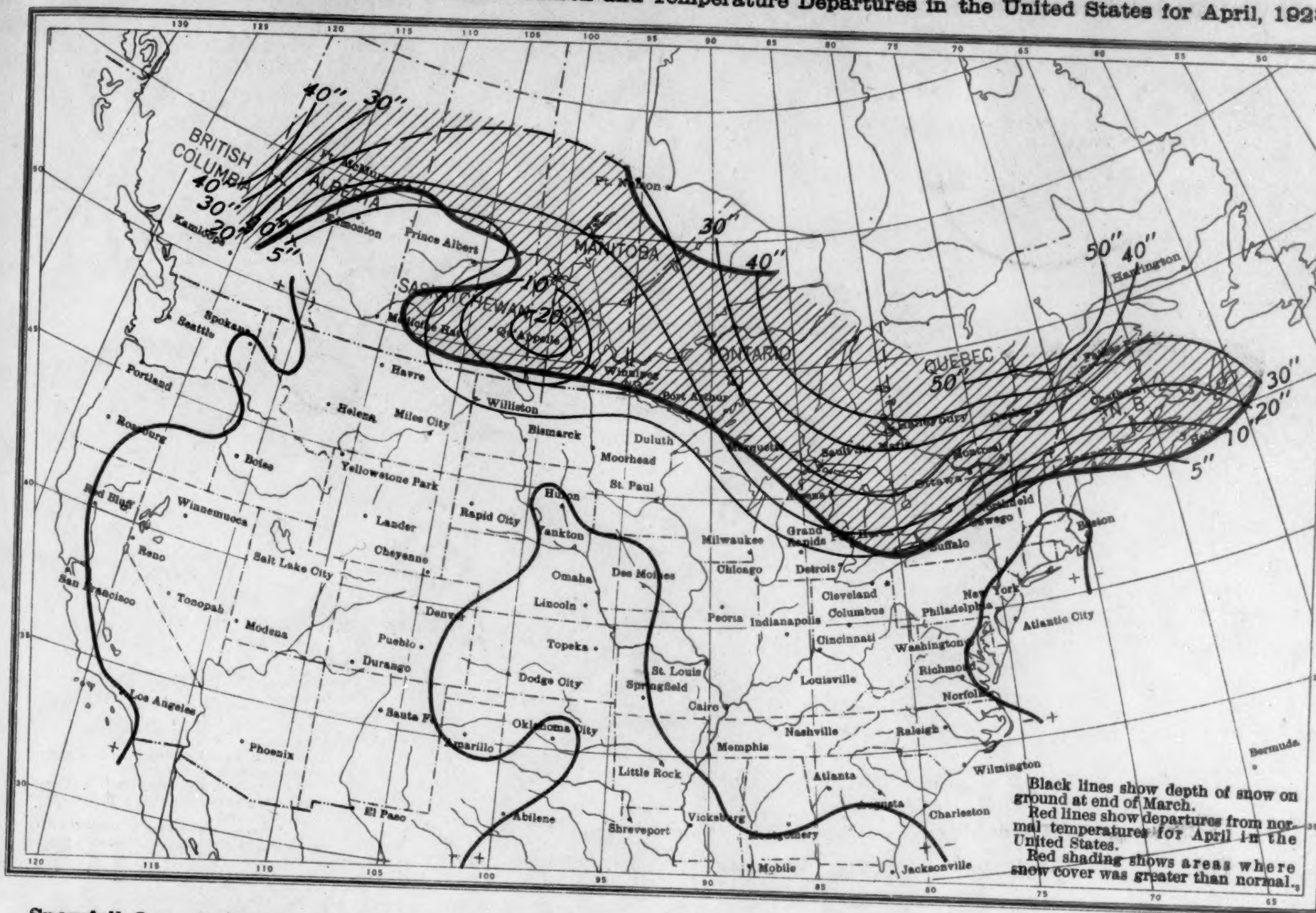
Snowfall Over Southern Canada at End of March and Temperature Departures in the United States for April, 1921



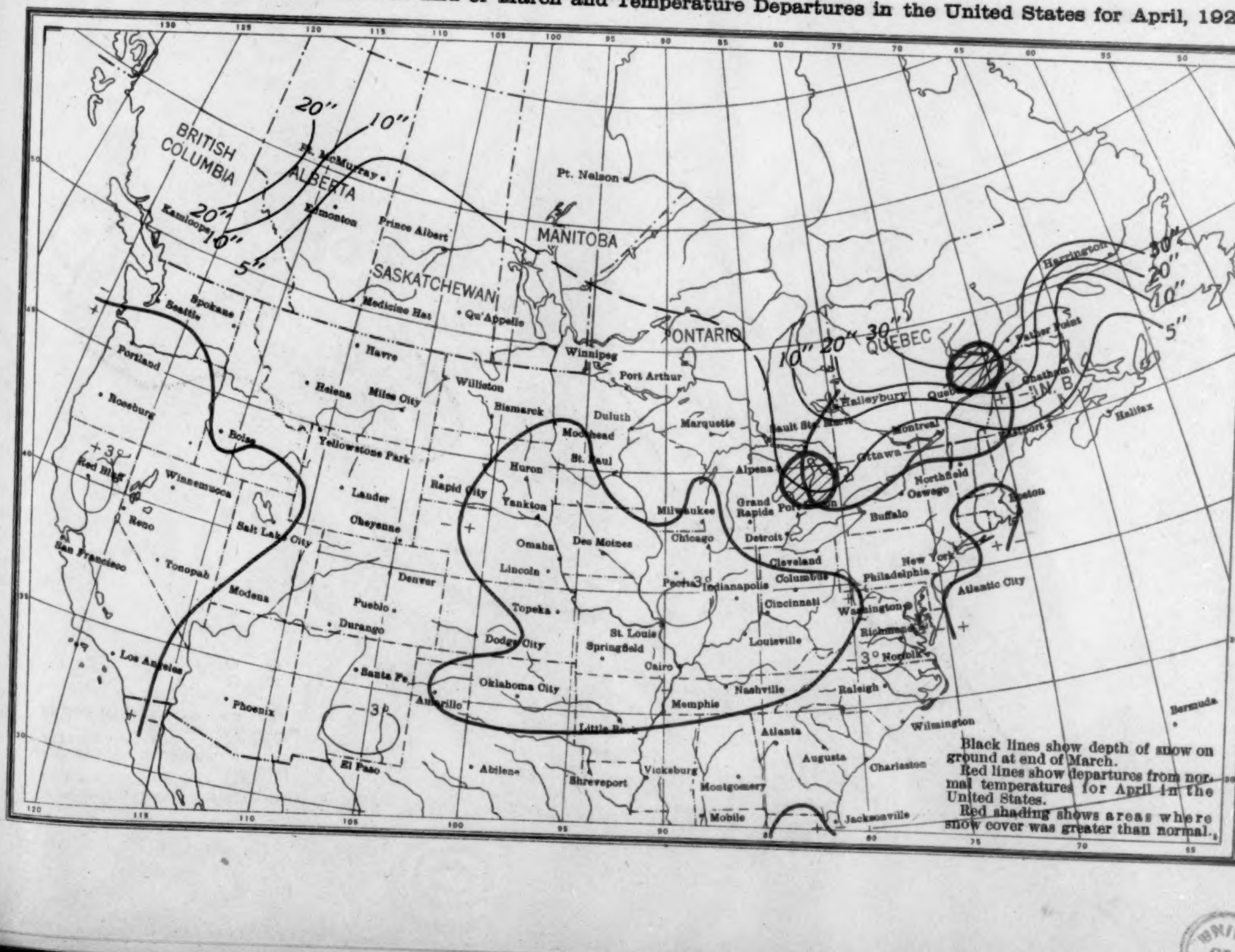
Snowfall Over Southern Canada at End of March and Temperature Departures in the United States for April, 1922



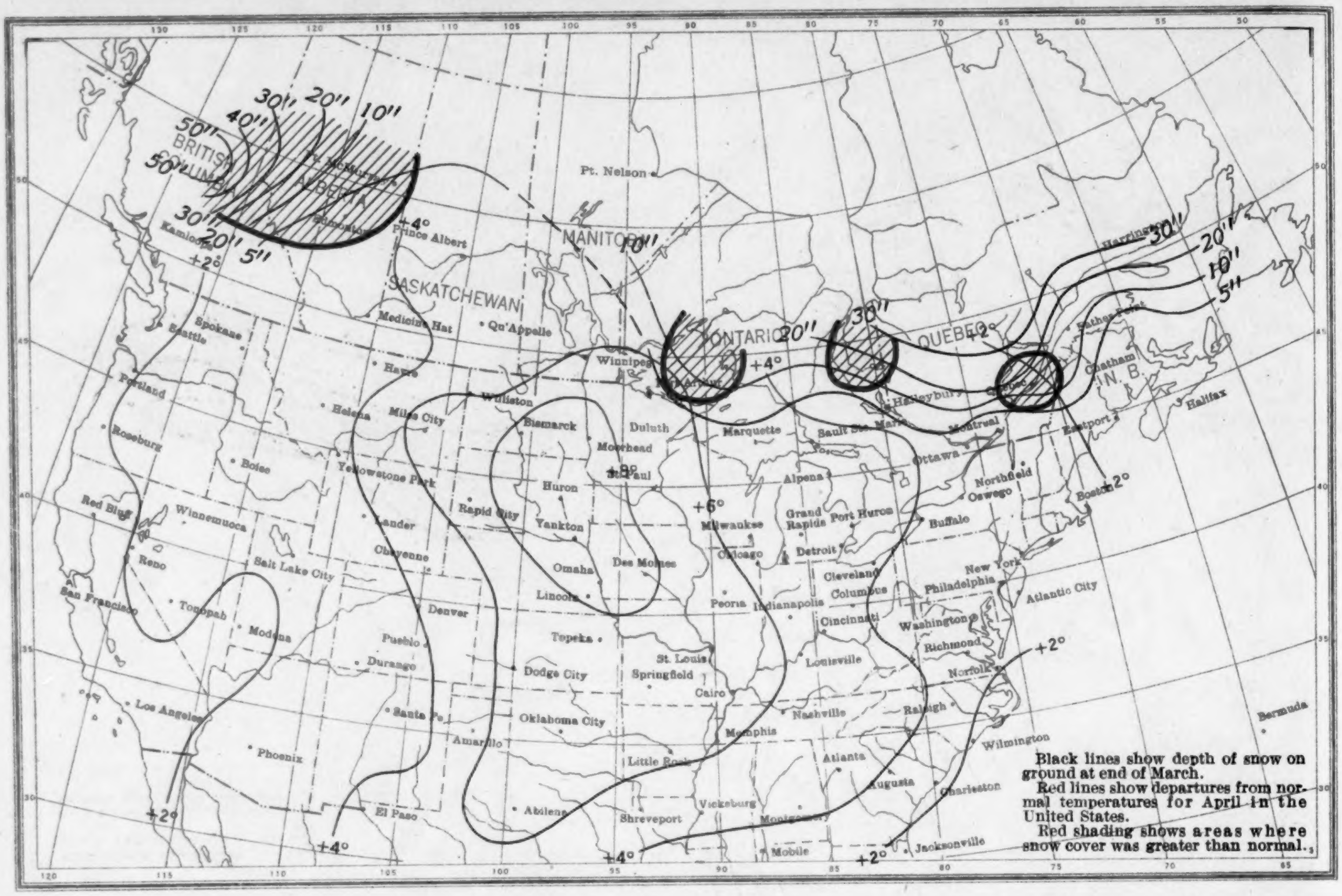
Snowfall Over Southern Canada at End of March and Temperature Departures in the United States for April, 1923



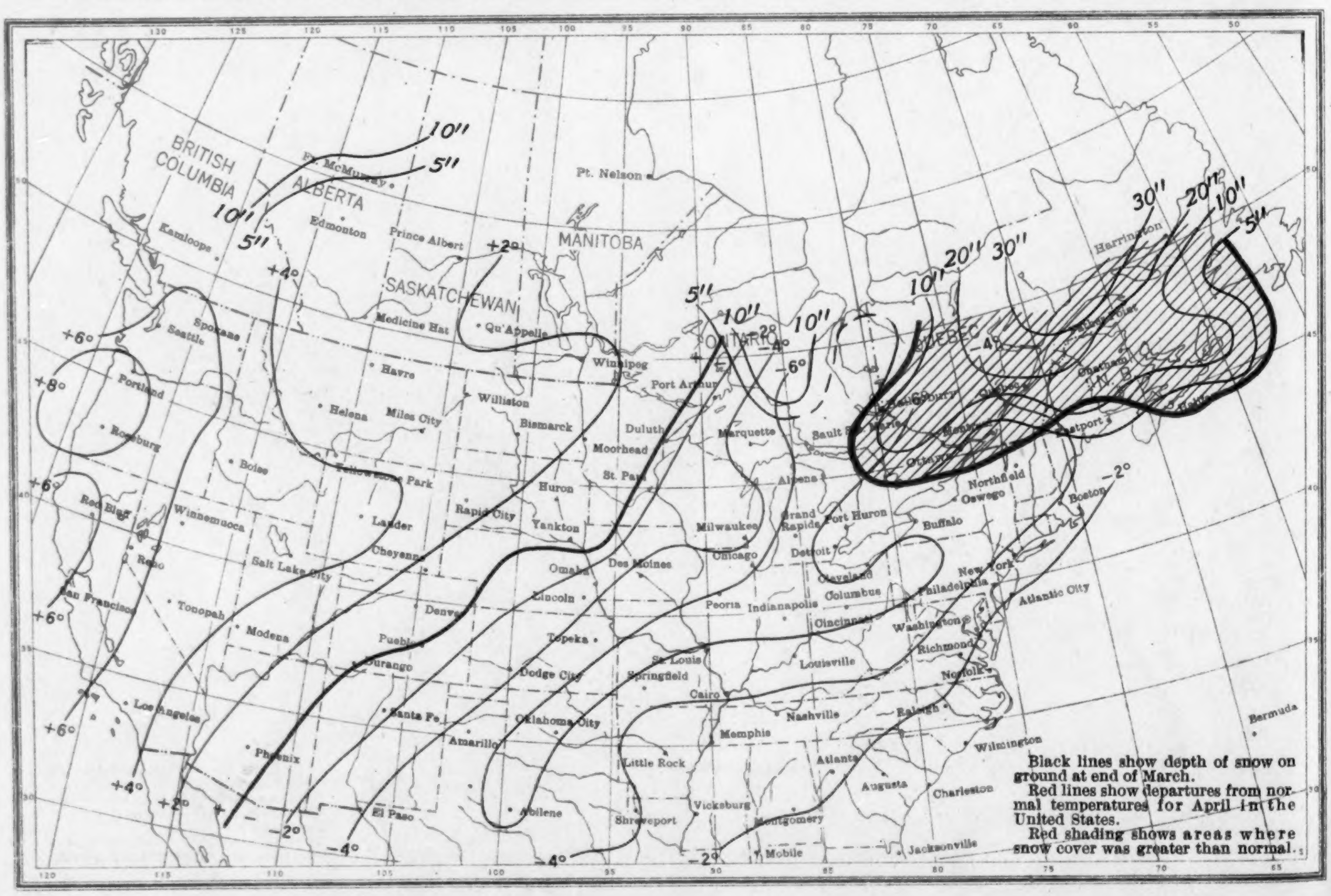
Snowfall Over Southern Canada at End of March and Temperature Departures in the United States for April, 1924



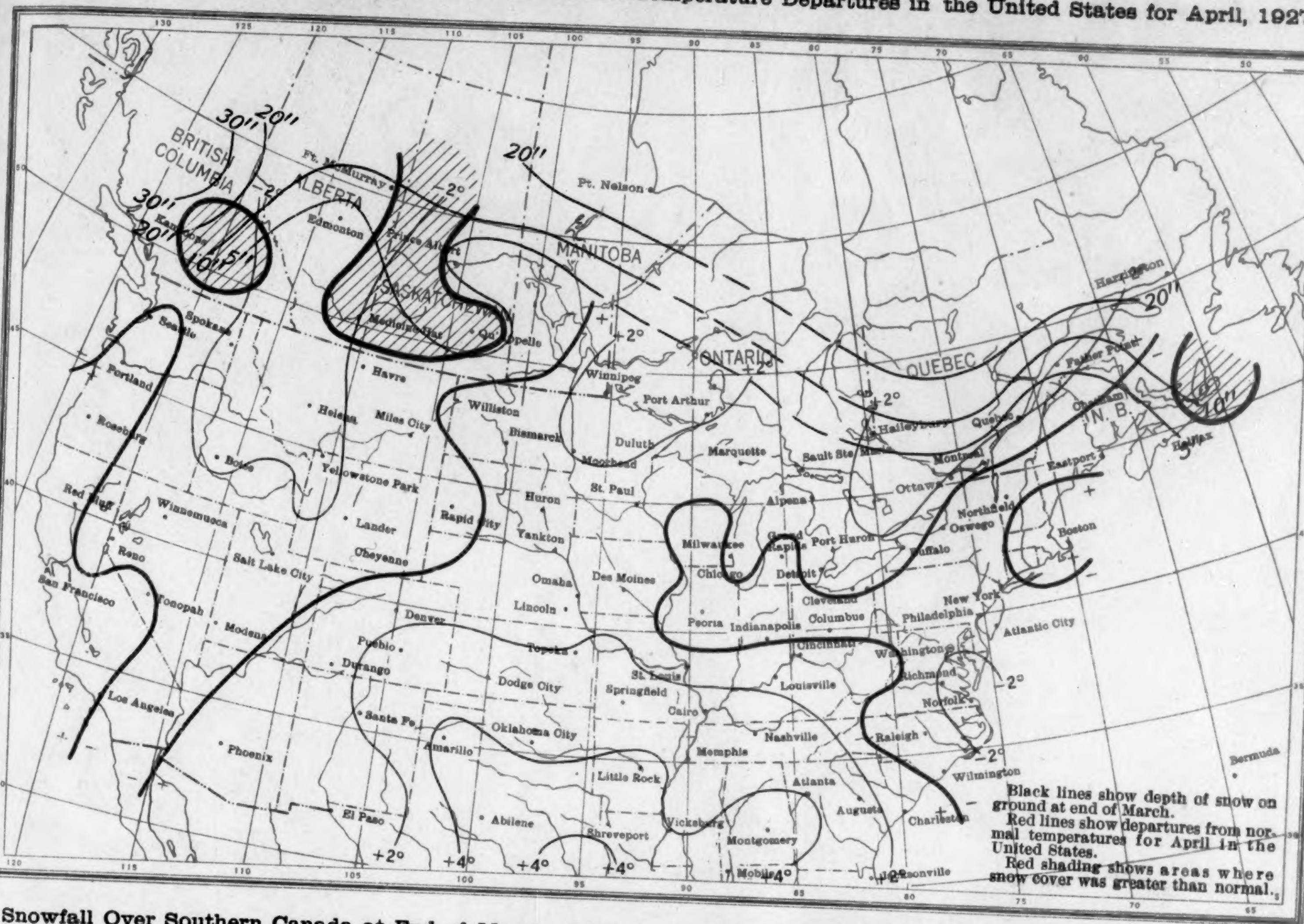
Snowfall Over Southern Canada at End of March and Temperature Departures in the United States for April, 1925



Snowfall Over Southern Canada at End of March and Temperature Departures in the United States for April, 1926

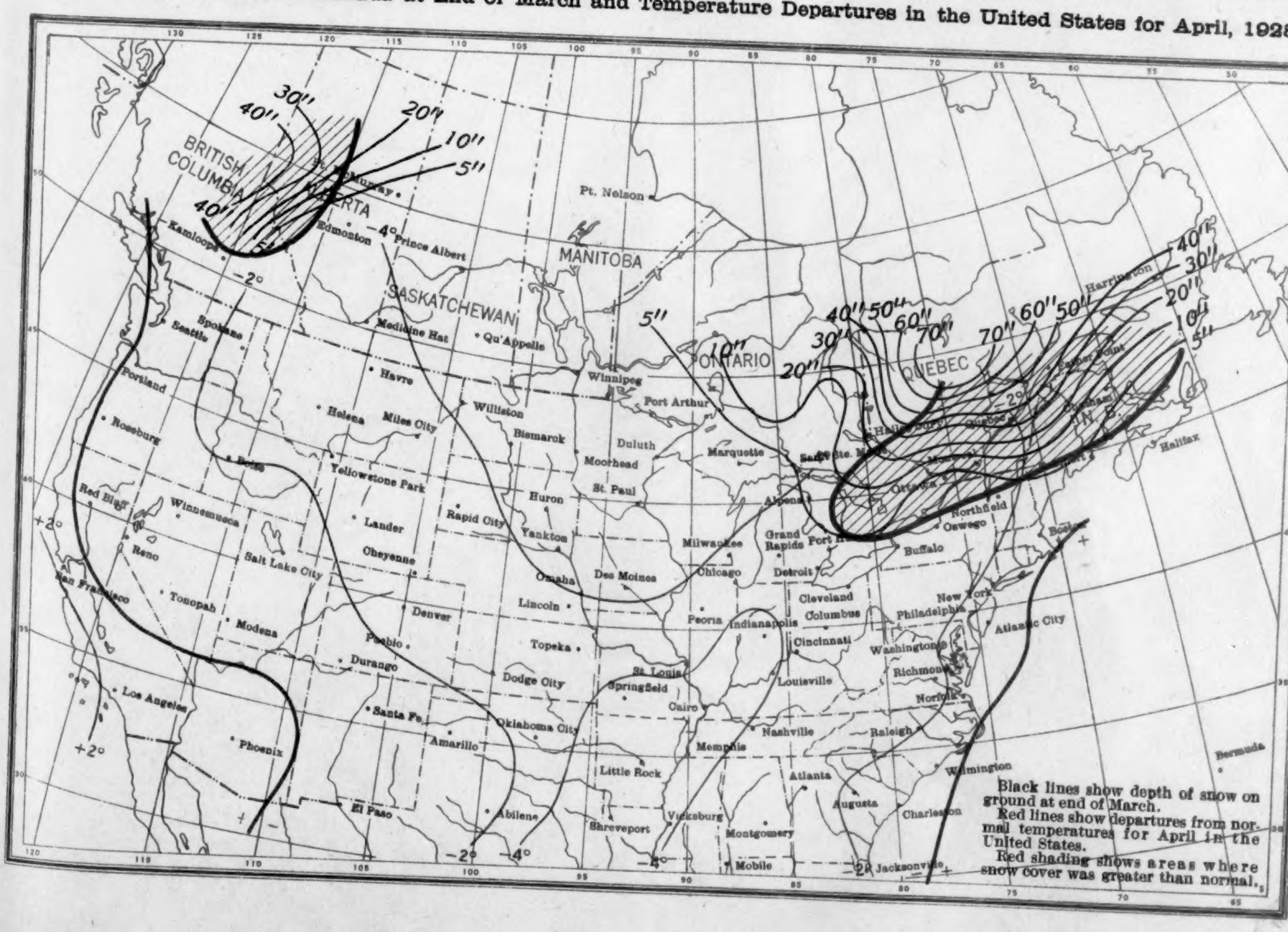


Snowfall Over Southern Canada at End of March and Temperature Departures in the United States for April, 1927



Black lines show depth of snow on ground at end of March.
Red lines show departures from normal temperatures for April in the United States.
Red shading shows areas where snow cover was greater than normal.

Snowfall Over Southern Canada at End of March and Temperature Departures in the United States for April, 1928



Black lines show depth of snow on ground at end of March.
Red lines show departures from normal temperatures for April in the United States.
Red shading shows areas where snow cover was greater than normal.

THE LAKE REGION

Years with April temperatures 1° or more below normal in the Lake Region, as represented by 10 well-distributed stations, were 1917 (−2.4°), 1920 (−3.7°), 1923 (−1.4°), 1926 (−5.6°) and 1928 (−2.4°).

1917.—At the end of March, a moderate snow blanket extended from the lower St. Lawrence Valley westward to the east of Lake Superior and to the North of Lake Huron, also over Saskatchewan and northern Manitoba. This condition was followed by April temperatures 2.4° below normal in the Lake Region.

1920.—Snowfall was above normal over Manitoba, central and southern Saskatchewan, and central and northern Alberta, but was considerably below normal over eastern Canada as a whole. The temperature departure for the Lake region was 3.7° below normal.

1923.—This year showed the deepest and most extensive snow cover at the end of March of any year in the period for which data are available. The region of above-normal depth extended from the Canadian Maritime Provinces westward over Quebec, Ontario, central and southern Manitoba, and Saskatchewan. Temperatures in the Lake region during April were 1.4° below normal.

1926.—Snow cover at the end of March was greater than the average in the St. Lawrence Valley, southeastern Ontario, and the Canadian Maritime Provinces. In the Lake region temperatures averaged 5.6° below normal.

1928.—The year 1928 was quite similar to that of 1926, so far as snow cover is concerned, and the temperatures in the Lake region averaged 2.4° below normal.

Of the five Aprils, with below-normal temperatures in the Lake region, three were preceded by above-normal snow cover at the end of March in Saskatchewan and Manitoba.

The years in which April temperatures were 1° or more above normal were 1921 (+7.0), 1922 (+1.5°), 1925 (+4.3°), and 1927 (+1.1°).

1921.—Snow cover was less than normal at the end of March over central and eastern Canada, being much below in the St. Lawrence Valley and in Ontario from Port Arthur eastward to Cochrane and Haileybury. The April temperature departure in the Lake region was +7.0°.

1922.—Snowfall was below normal in the St. Lawrence Valley, western Ontario, and southeastern Manitoba, being followed by a temperature departure of +1.5° in the Lake region.

1925.—Snow cover was below normal in the St. Lawrence Valley, except Quebec, in eastern Ontario, except at Cochrane, and in Saskatchewan and Manitoba, being followed by April temperatures 4.3° above normal in the Lake region.

1927.—Snow cover was below normal over Canada, except in Saskatchewan and at Kamloops and Sydney, being followed by an April temperature departure of +1.1° in the Lake region.

In all four of these warm Aprils in the Lake region, a snow cover was below normal in the St. Lawrence Valley.

We have now considered April temperatures in two areas, namely, the North Atlantic States and the Lake region, as associated with snow cover over Canada at the end of March. Let us now consider a broader territory, comprising the northeastern Rocky Mountain region, the Plains States, the Ohio, and middle and upper Mississippi Valleys, the Lake region, and the North Atlantic States. Districts 1, 3, 4, 5, and 7. (See Chart No. 1.) The most consistently cold Aprils were in order of degree of coldness, 1920 (−4.0°), 1928 (−2.4°), 1917 (−1.7°), and 1918 (−1.5°), and the most consistently warm ones in the order of warmness were 1925 (+5.2°), 1921 (+3.8°), 1922 (+1.5°), and 1927 (+1.3°).

1920.—Snowfall at the end of March was above normal in Manitoba, Saskatchewan, and part of Alberta, and below normal elsewhere in Canada, being much below over Ontario and the St. Lawrence Valley.

1928.—Snow cover was above normal in the St. Lawrence Valley, New Brunswick, and British Columbia, and below normal elsewhere in Canada.

1917.—Snowfall was above normal in the lower St. Lawrence Valley, northern Ontario, Saskatchewan, and northern Manitoba, and below normal over southeastern Manitoba and southeastern Ontario.

1918.—Snow cover over all of Canada was below normal except at Barkerville, Chatham, Halifax, and Fort McMurray.

Two of the four cold Aprils had above-normal snow cover over Saskatchewan and northern Manitoba, but no systematic relation is apparent.

1925.—Below-normal snow cover prevailed at the end of March over Saskatchewan, Manitoba, and southern Ontario, and above-normal cover over British Columbia, northern Alberta, part of northern Ontario, and at Quebec.

1921.—Snow cover was below normal over all Canada except northeastern Saskatchewan and northern Manitoba, being much below over Ontario and the St. Lawrence Valley.

1927.—Snow cover was below normal over Manitoba, northeastern Saskatchewan, Ontario, the St. Lawrence Valley, and the Canadian Maritime Provinces, and above normal in British Columbia, southern and western Saskatchewan, part of Alberta, and at Sydney.

1922.—Snow cover was mostly below normal except in portions of Saskatchewan and Manitoba and northeastern Ontario.

These four cases of warm Aprils seem quite consistent as to antecedent snow conditions, as cover over most all of Canada was below normal at the end of March in each case.

However, the author is forced to the conclusion that considering all available data from stations in southern Canada, there is little if any consistent relationship between snow cover at the end of March in southern Canada and April temperatures in our States immediately south of the Canadian border line.

It is to be regretted that depth-of-snow observations are not available from higher-latitude stations in central and eastern Canada, in which case, no doubt, more satisfactory results could have been obtained.

It seems fair to suppose that the temperatures in our northern border States are determined by several factors, at least; one of which is snow cover over Canada and while the results obtained in this study indicate quite clearly that the snow cover over southern Canada is not the main factor, nevertheless the snow cover undoubtedly has its influence.

Similar comparisons have been made between snow cover at the end of February with temperatures in northern States in March, but the results are as disappointing as those for April.

TABLE 1.—*Snow on ground at end of March*

	Dawson	Barkerville	Fort McMurray	Edmonton	Battleford	Prince Albert	Le Pas	Calgary	Medicine Hat	Swift Current	Quappelle	Minnedosa	Winnipeg	Port Nelson	Port Arthur	White River
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1916	----	----	T.	----	----	4.0	9.0	0	----	0	4.0	4.0	4.0	81.0	14.0	*18.0*
1917	----	----	----	2.0	*5.0*	8.0	9.0	0	*0*	0	8.0	T.	T.	----	5.0	30.0
1918	----	30.0	10.0	T.	*T.*	*0*	0	0	0	*0*	*0*	0	*0*	9.5	0	12.0
1919	14.0	22.0	12.0	0	*2.0*	4.0	3.0	*0*	0	0	3.0	5.0	T.	20.0	*T.*	T.
1920	22.0	3.5	5.5	6.5	8.0	6.0	*10.0*	1.5	T.	*3.0*	6.0	9.0	3.0	40.0	0	0–12
1921	22.0	25.0	6.0	0	*4.0*	10.0	10.0	0	0	*0*	0	2.0	T.	----	0.5	8.0
1922	----	26.0	16.5	----	*10.0*	11.0	7.3	----	----	----	10.0	2.0	*2.0*	12.0	*T.*	12.0
1923	42.0	44.0	11.5	T.	*T.*	T.	8.0	0	T.	7	16.0	22.0	9.0	2.5	15.0	38.0
1924	21.0	26.0	8.5	2.0	*1.0*	*1.0*	2.0	*T.*	0	*0*	0	T.	*T.*	----	2.2	T.
1925	30.0	55.0	5.0	4.0	*1.0*	T.	1.0	----	----	----	0	T.	T.	----	14.0	7.0
1926	14.0	----	----	T.	*T.*	0	T.	*T.*	*T.*	T.	T.	T.	T.	----	2.0	12.0
1927	13.0	30.0	13.5	2.0	6.0	2.0	2.0	----	*3.0*	*4.0*	6.0	2.0	*2.0*	26.0	T.	0–15
1928	29.0	42.0	T.	0	*1.5*	3.0	*3.0*	*T.*	0	*T.*	*T.*	T.	0	----	4.0	14.0
Average	23.0	27.6	8.0	1.5	3.2	3.8	5.0	0.2	0.3	1.3	4.1	3.5	1.5	27.3	4.4	13.5

NOTE.—Figures in italics are interpolated.

TABLE 1.—*Snow on ground at end of March*—Continued

	Cochrane	Haileybury	Stonecliffe	Parry Sound	Southampton	Ottawa	Montreal	Quebec	Father Point	Chatham	Harrington	Sydney	Halifax	Anticosti
	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1916	36.0	24.0	18.0	*12.0*	----	7.0	T.	8.0	24.0	T.	----	T.	2.0	----
1917	*32.0*	28.0	6.0	T.	0.5	T.	T.	20.0	24.0	6.0	4.0	0	T.	23.0
1918	*12.0*	----	6.0	T.	1.0	T.	3.0	18.0	*19.0*	*10.0*	42.0	T.	3.5	16.0
1919	*5.0*	15.0	6.0	*3.0*	*0*	2.5	13.0	8.0	30.0	9.0	3.0	0	T.	6.0
1920	*T.*	T.	4.0	*3.0*	2.0	0	T.	1.0	10.0	4.0	----	0	0	42.0
1921	*5.0*	T.	*T.*	*T.*	*0*	0	0	1.2	*6.0*	0	*10.0*	0	T.	12.0
1922	*22.0*	20.0	*1.0*	T.	4.0	1.0	3.0	1.8	10.0	0	----	6.0	4.0	----
1923	*40.0*	----	*20.0*	24.0	15.0	14.0	17.4	44.0	54.0	22.0	----	34.0	10.0	38.0
1924	*5.0*	----	*5.0*	6.0	5.0	1.0	1.0	28.6	*21.0*	8.0	36.0	4.0	T.	7.0
1925	*28.0*	----	*8.0*	T.	*T.*	*T.*	T.	20.0	*19.0*	T.	----	0	*0*	19.0
1926	0	----	*11.0*	10.0	3.0	*5.0*	6.0	22.0	*30.0*	12.0	----	12.0	5.0	32.0
1927	*8.0*	----	*1.0*	T.	T.	*1.0*	*2.0*	3.0	*9.0*	4.0	----	16.0	T.	18.0
1928	10.0	----	*12.0*	12.0	6.0	5.0	15.0	48.0	*30.0*	8.0	----	1.0	T.	----
Average	15.6	14.5	7.5	5.4	3.0	2.8	4.3	17.2	22.0	6.4	19.0	5.6	1.9	21.3

FLIGHT OF RS-1, SAN ANTONIO, TEX., TO SCOTT FIELD, ILL.[1]

By WILLIAM E. KEPNER, Captain, Air Corps, U. S. A.

When over Memphis we were still unable to get in touch with Scott Field. The sky to the west had been gradually thickening up. The sun was still shining where the ship was. At 1: 20 p. m. there appeared a number of small rains traveling rapidly eastward across our path several miles ahead. The ship was headed about and we circled one of these with very little effect on the ship's stability. The ship was slowly circling to maneuver between several of these shower areas, when there appeared a specially favorable opening to the west. It looked as though there was a distinct wind shift line to the north and it was traveling nearly east. It was decided to fly into the apparently clear area to the west of Memphis and thus be well in rear of the squalls to the north.

Just as the ship was well on her course to the west and appeared to be running safely around the rain area, a deadly looking line squall, already perfectly developed, came racing across the sky from the northwest on a path that bid fair to interrupt the ship. To turn the ship either way was to lose time. The ship was allowed to drift slightly toward the rain on our left and the motors turned up to where the air speed was 53 miles per hour. However, the ship was being caught in the storm on our left. It was dragged rapidly in toward the center of the small disturbance and shortly afterward began to pitch and toss violently with an increasing tendency to rise in spite of even a 25° angle of descent. There was a sensation of being dragged backward and upward, with the ship out of control. There was nothing left but to run all motors at full speed. The ship was momentarily headed to the right and at an air speed of 65 miles per hour began to leave the rain squall. We were just out with a sickening plunge downward, when the line squall in the northwest appeared to be practically on top of us. This "line" was a coal-black body about 1,000 feet above the ground, with a bluish green color running underneath and all the way to the ground. From the black line great chunks of cloud were frequently thrown off, with an appearance of being immediately torn to pieces in the disturbed air just beneath. The airspeed indicator began to jump from gusts that we began at once to feel on the ship's nose. The ship would shudder as though it had bumped into something. The ship was turned as quickly as possible with such high speed, to the left and around the rear of the storm we had just left. We barely missed the northwest line squall and were in fair weather, heading southeast with the motors again throttled to cruising speed. There was a line of squalls bearing to the south, west, and northeast.

An inspection of the ship disclosed that the rigid nose had given way just where the longitudinals meet and make the nose tip. The solid cone plate, to which all girders were bolted, had broken all around and each longitudinal end was swinging free. Only two longitudinals beside the main keel structure remained solidly in place. The entire top of the nose had given way at the tip. A couple of the spacer girders that make a ring about half way back were crushed, and the nose cover was torn somewhat. The longitudinals were pushed back into place and the ends laced together with cable in an effort to approximate a new nose tip. The repair seemed satisfactory under the circumstances.

It was then 2:10 p. m. and we were traveling east. The squalls appeared to make a line across the north, west, and south. I planned to fly east and, if possible, land near Nashville, Tenn., refuel, and then outrun the storm to Langley Field, Va.

At 2:30 p. m. another line appeared across the east, and we seemed to be trapped completely. The circle of storms was about 30 miles in diameter. This was rapidly becoming less and less. When the border appeared about 5 miles away in all directions, there was a small break to the south. It was apparently our only chance, and I decided to take it. We could not afford to be caught in the center of all those approaching storms.

We moved cautiously into the opening southward. There was rain to our left and another line squall, not so well developed, on our right. With a crippled nose, it was decided to push the ship only so far as was absolutely necessary. The ship was alternately dragged first to the left, then to the right, as we would be near first one storm, then the other. When it appeared we were successfully getting through, there was an icy draft through the control car from our right, and the ship was running directly sideways to the left at an increasing

[1] Extract from official report made to Chief of Air Corps, Washington, D. C., October 18, 1928.

speed until I would estimate it to be at least 50 miles per hour. Our speed forward was 53 miles per hour. The ship was again turned to the right, but not daring to give it any more speed forward, we were unable to pull out as had been the case in the first squall. The ship was sucked rapidly into the storm on our left and quite suddenly began to rise rapidly in a very cold air that was attended by a veritable cloud-burst of water. All available valves were opened to relieve the internal pressure. As the ship soared up there was a sensation of being tossed about like a leaf, with violent shudders passing through the ship. The suspension cables on the cars shrieked with a sound similar to a diving airplane. It seemed as though something must give way in the ship's structure. The bag over the cars seemed to breathe with a great surging of gas that caused a change in the apparent cross-section shape.

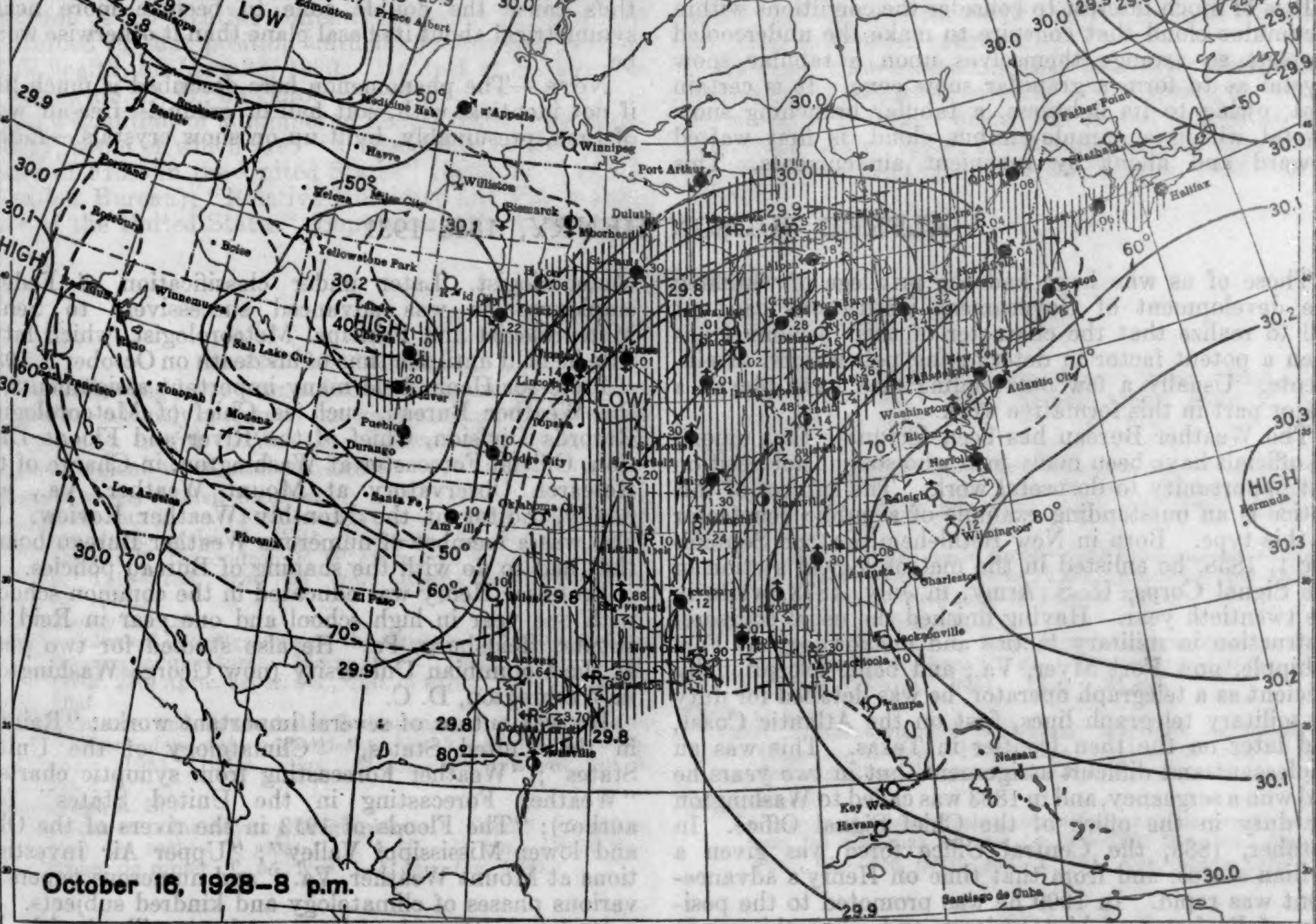
The elevators were put "hard down," and at 2,000 feet altitude the ship went into a dive of approximately 45°. Gasoline and ballast were dropped to check the fall. Everyone had to hang on, as it was impossible to stand up. All the way down the elevators were "hard up," and the ship leveled off just in time to avoid crashing. Then it immediately started rising again, very rapidly. This time it did not reach the same altitude, but repeated the dive, and again came out just in time to avoid crashing. There was apparently a blanket of very dense air on the ground that each time assisted the ship to avoid crashing. Due to our low air speed, we were not coming out of the storm very fast, and it was a battle for 15 minutes of at least six or seven sickening ascents and descents that gradually dampened out until we were finally out in a clear area to the south. We had barely reached the storm's edge when a blinding flash of lightning occurred in the center of it, and near the tail of our ship. It, however, did no damage. The wind outside this area was flowing gently from the north and a fog was forming just off the ground. The sky was clearing to the northwest, and the ship was headed in that direction. We were then 50 miles southeast of Memphis, Tenn.

An inspection of the nose showed considerable further damage. The laced ends had held, but due to the consequent flexibility, the cross bracing girders had practically all crumpled. Eight of the spacer girders had been crushed and several small holes had been punched in the gas envelope. The exposed ends of broken girders were wrapped with blankets for a padding to prevent further punctures of the gas bag. The holes were repaired. A test of flying showed that we could safely proceed at 40 miles per hour. It was then 4:30 p. m.

We received a message that conditions were favorable at Scott Field and proceeded in that direction, where we landed at 10:10 p. m., October 16, 1928.

DISCUSSION

At the time of the bad weather experienced by the *RS-1* a trough of low pressure extended from Michigan southwestward to eastern Kansas, and thence southward to the mouth of the Rio Grande. (See figure.) This trough was a part of a very extensive area of low pres-



October 16, 1928–8 p.m.

sure that had been drifting slowly eastward for several days prior to October 16. During this period warm, humid air from the Caribbean Sea and the Gulf of Mexico had been steadily moving northward over the Mississippi Valley, while a HIGH from the Pacific Ocean had been advancing eastward over the Plateau and Rocky Mountain regions, bringing cooler air down the eastern slope of the Rockies and over western Texas by 8 a. m. of the 16th. The kite flight at Groesbeck, Tex. (started at 5:54 a. m.), shows that there had been an increase in both humidity and temperature up to 2 kilometers above the surface, and a slight decrease in temperature at the top of the flight (about 2,300 meters above the surface) since the flight 24 hours previously. This condition, increase of the lapse rate and of the humidity below the 2-kilometer level, rendered the air quite unstable and made the conditions favorable for active convection and the development of more or less violent thunderstorms a little later in the day in eastern Texas.

The air movement being from southwest to northeast, this same condition extended rapidly northeastward over Arkansas and extreme western Tennessee during the day. It was in the late afternoon that conditions quite similar to those shown by the Groesbeck kite flight set in over extreme western Tennessee and resulted in the violent thunderstorms experienced by the *RS-1*.—*Chas. L. Mitchell.*

CONICAL SNOW

By WILSON A. BENTLEY

Every late autumn and early spring there occur at Jericho, in northern Vermont, and of course at other similar locations, several falls of conical snow, and also an occasional one in winter. This sort of snow comes only out of cumulo-nimbus clouds, and more commonly when the surface temperature ranges from 34° to 44° F. Conical snowflakes have a granular texture and are built up mainly from countless undercooled cloud droplets that have frozen loosely together. Their greatest diameter ranges from one-sixth to one-third inch. The writer assumes, from a long-time study of this form of snow, that the nuclei usually, if not invariably, consist of branching tabular crystals.

It is of much interest to consider the conditions within a cumulus cloud that conspire to make the undercooled droplets so arrange themselves upon a tabular snow crystal as to form a granular snow cone. It is certain that, owing to its lightness, a tabular branching snow crystal within a cumulo-nimbus cloud, is first wafted upward and about by turbulent air currents. This causes it to become thickly coated on both sides with frozen cloud droplets, or granular snow. It now begins to fall with the denser side turned downward, and since it falls faster than the cloud droplets light granular material then rapidly collects on (is caught by) the under face thereby destroying the former gravitational equilibrium of the mass and causing it to upset, whereupon the granular snow is caught exclusively, or nearly so, by the new underside, and thus the whole converted into a more or less well-defined double cone with its abutting bases on the opposite sides of the initial tabular crystal. It is conceivable, given a cumulo-nimbus cloud of sufficient thickness, that additional upsettings might occur and thus cause the double cone to become more nearly symmetrical about its basal plane than it otherwise would be.

NOTE.—The phenomenon here described is much like, if not identical with, soft hail or graupel—free-air wads of rime, presumably, built up on snow crystals.—*Editor.*

ALFRED JUDSON HENRY, 1858–1931

Those of us who have had the privilege of watching the development of Government institutions can not fail to realize that the character of their personnel has been a potent factor in determining policies and attainments. Usually a few outstanding men have played a major part in this formative work.

The Weather Bureau has been fortunate that among its officials have been many men who sought not position but opportunity to do useful work. The subject of this notice is an outstanding example of a public benefactor of this type. Born in New Bethlehem, Pa., on September 1, 1858, he enlisted in the meteorological section of the Signal Corps, U. S. Army, in July, 1878, while in his twentieth year. Having finished the usual course of instruction in military tactics and meteorology at Fort Whipple, now Fort Myer, Va., and being exceptionally efficient as a telegraph operator, he was detailed for duty on military telegraph lines, first on the Atlantic Coast, and later on the then frontier in Texas. This was an unpleasant and difficult assignment, but in two years he had won a sergeancy, and in 1883 was called to Washington for duty in the office of the Chief Signal Office. In October, 1888, the Central Office force was given a civilian status, and from that time on Henry's advancement was rapid. In 1900 he was promoted to the position of Professor of Meteorology, and when this grade was abolished in 1910 his designation became simply Meteorologist. Later under classification of Federal employees he was advanced successively to Senior Meteorologist and Principal Meteorologist, which latter title he held until the time of his death on October 5, 1931.

Professor Henry held many important assignments, in the Weather Bureau, such as Chief of Meteorological Records Division, Chief of the River and Floods Division, Official Forecaster at Washington, in Charge of the Research Observatory at Mount Weather, Va., and finally, Editor of the Monthly Weather Review. He also was a member of numerous Weather Bureau boards that had to do with the shaping of Bureau policies.

Professor Henry was educated in the common schools, with one year in high school and one year in Reid Institute, Reidsburg, Pa. He also studied for two years at the Columbian University (now George Washington) in Washington, D. C.

He was author of several important works: "Rainfall in the United States," "Climatology of the United States"; "Weather Forecasting from synoptic charts"; "Weather Forecasting in the United States" (coauthor); "The Floods of 1913 in the rivers of the Ohio and lower Mississippi Valley"; "Upper Air Investigations at Mount Weather, Va.;" and numerous papers on various phases of climatology and kindred subjects.

Professor Henry's fellow workers will cherish his memory, not alone for his scientific attainments, but

above all for himself. He was a fine type of a Christian gentleman. Generous of his time and means and of a retiring disposition, yet he always was ready to give helpful counsel to his younger associates. The writer served under and with Professor Henry for more than 40 years, a part of that time at Mount Weather, where most of the staff lived under the same roof, and in all these years neither knew nor heard of any unkind or unjust act on his part.

Professor Henry was a fellow of the American Association for the Advancement of Science, and of the American Meteorological Society. He was a member of the American Geophysical Union, and a former secretary of its Meteorological Section; a former secretary of the National Geographical Society; and a member of the American Association of Geographers, the Washington Academy of Sciences, and the Philosophical Society of Washington. He was fond of outdoor sports. In his younger days he was a base ball enthusiast and a bicylist with "century runs" to his credit. In later years golf was his recreation. He also was an amateur photographer of merit, and some of his cloud photographs have been used in cloud literature as types of the classes they represent.

In character, in industry, in loyalty, in devotion to his work, which led him to take advantage of every opportunity to prepare himself for greater usefulness, his life and its successes should be an incentive to younger men who now enjoy opportunities greater than were his. Above all they must remember that the foundation of his success was *character*.

The death of his talented daughter, Helen, in 1930, an only child, was a severe blow, from which he never fully recovered. His wife, Mrs. Jessie H. Henry, survives him.—*Herbert H. Kimball.*

PRESTON C. DAY, 1859–1931

Dr. P. C. Day was born in Frederick County, Md., October 21, 1859. He entered the Signal Corps (Weather Bureau) June 29, 1883, and after the usual six months of training at Fort Myer (formerly Fort Whipple) began his service of more than 46 years at the Central Office.

He was a man of sterling character, much liked by every one, a hard and conscientious worker, doing everything properly and on time. He was graduated from the National College of Pharmacy, Washington, D. C., on May 7, 1906.

Doctor Day was made Chief of the Climatological Division of the Weather Bureau September 12, 1910, and continued in that position until his retirement, because of ill health, on May 28, 1930. He died at his home in Washington, D. C., on October 21, 1931.

He was author of a number of papers relative to climatology, some of which are: "A Discussion of the Occurrence of Frost in the United States" (Bulletin V, of the Weather Bureau); "Relative Humidity and Vapor Pressure of the United States" (Supplement No. 6, Monthly Weather Review); "A Discussion of the Climate of the United States by Sections" (Bulletin W, of the Weather Bureau); a paper on the Climate of France and Belgium, in the Monthly Weather Review for October, 1917; a discussion of the "Cold Winter of 1917–18," Monthly Weather Review for December, 1918; and "A Treatise on the Winds in the United States," published in the Yearbook of the Department of Agriculture.

Doctor Day was editor of the Monthly Weather Review from 1910 to 1913, inclusive, editor of the National Weather and Crop Bulletin for a number of years, and editor of the Snow and Ice Bulletin from 1910 until the time of his retirement.

He was a fellow of the American Meteorological Society, and at its Washington meeting in the spring of 1926 he presented a thorough discussion of the precipitation of the Great Lakes region, a contribution that appeared in the Monthly Weather Review, March, 1926.—*M. C. Bennett.*

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C. Fitzhugh Talman, in charge of Library

RECENT ADDITIONS

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SOLAR OBSERVATIONS

SOLAR RADIATION MEASUREMENTS, OCTOBER, 1931

By HERBERT H. KIMBALL, in charge, Solar Radiation Investigations

For a description of instruments employed and their exposures, the reader is referred to the January, 1931, REVIEW, page 41.

Table 1 shows that solar radiation intensities averaged above the normal values for October at Washington and close to normal at Madison and Lincoln.

Table 2 shows an excess in the total solar radiation received on a horizontal surface at Lincoln, Chicago, New York, Pittsburgh, and Fresno as compared with October normals for the respective stations; close to normal at Madison, and a deficit at Washington and Twin Falls.

Skylight polarization measurements made on 4 days at Washington give 63 for the mean percentage of polarization, with a maximum of 70 per cent on the 20th. At Madison, polarization measurements made on 10 days give a mean of 65 per cent with a maximum of 76 per cent on the 18th. These are above the corresponding averages for each station in October.

CORRECTION.—Owing to a misunderstanding as to the reduction factor that was required to reduce scale readings on the register to heat units the weekly averages given in Table 2 for September, 1931, for Twin Falls are too small. For the successive weeks they should read 523, 512, 398, and 464 and the departures from normal should be −9, +5, −77, and +29.

SOLAR RADIATION MEASUREMENTS AT FAIRBANKS, ALASKA

A request for the installation of apparatus for recording the intensity of solar radiation at Fairbanks was made some time ago by the agricultural experiment station at that place. It was not immediately complied with for the reason that the cover of the Weather Bureau thermoelectric pyrheliometer was secured to the metal base by cement, which did not make a permanently tight joint. Occasionally moisture condensed on the inside of the cover, which could be removed only after the instrument had been recalled to the central office.

The Eppley thermoelectric pyrheliometer is hermetically sealed inside a glass bulb, which has been carefully dried out. Little difficulty from condensation of moisture inside the bulb is therefore to be expected.

An Eppley pyrheliometer, recording on an Englehard microammeter was installed at Fairbanks early in August, 1931. It is exposed on a support 10 feet above the roof of the office building, where it has unobstructed exposure to the entire sky down to the horizon in all directions. The latitude of Fairbanks is 64° 52′ N., and the altitude of the pyrheliometer above sea level is about 500 feet.

Fairbanks is much farther north than any other station at which solar radiation measurements of this character are now systematically made. The nearest approach to it is Sloutzk, U. S. S. R., latitude 59° 41′ N. Records for the period September 4, 1927, to August 9, 1928, were, however, obtained at Green Harbor, Svalbard, latitude 78° 00′ N. They are summarized in the MONTHLY WEATHER REVIEW, April, 1931, vol. 59, p. 154. Green Harbor is well within the Arctic Circle, while Fairbanks is 1° 31′ below it. However, records from the latter station can not fail to be of interest.

The mean daily totals of radiation for each week in October are given in Table 2. The maximum daily amounts for each week are 61, 44, 42, and 40, respectively, and the corresponding hourly maxima are 11.9, 7.5, 8.1, and 7.5.

For the last three weeks in August the average daily amounts are, respectively, 322, 421, and 245, and the corresponding daily maxima are 486, 479, and 427. In September the averages for each week are, respectively, 55, 57, 40, and 46, while the maxima are 119, 103, 57, and 75. The average for the third week in August happens to be the same as the normal value for Washington for that week. All other averages are much less. In September the maximum daily amounts are less than the daily normals at any station in the United States in midwinter except in the smoky city of Chicago.

TABLE 1.—*Solar radiation intensities during October, 1931*

[Gram-calories per minute per square centimeter of normal surface]

Washington, D. C.

Date	8 a.m. 75th mer. time	78.7° A.M.	75.7° A.M.	70.7° A.M.	60.0° A.M.	0.0°	60.0° P.M.	70.7° P.M.	75.7° P.M.	78.7° P.M.	Noon Local mean solar time
	e.	5.0	4.0	3.0	2.0	[1] 1.0	2.0	3.0	4.0	5.0	e.
	mm.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	mm.
Oct. 3	12.24				0.86	1.19					11.38
Oct. 5	11.38	0.56	0.67	0.82	0.99						13.13
Oct. 10	7.57	0.68	0.81	0.96	1.13						7.04
Oct. 12	5.36	0.97	1.05	1.18							4.17
Oct. 13	4.37	0.59	0.95	1.09	1.15						4.37
Oct. 17	5.56	0.94	1.02	1.12	1.32						4.95
Oct. 19	5.36	0.80	0.90	1.08	1.27	1.48	1.29	1.09	0.97	0.83	4.37
Oct. 20	5.56	0.90	0.98	1.14	1.29	1.47	1.25	1.13	1.00	0.90	4.75
Oct. 21	7.04			0.78	1.02		1.00	0.72			8.18
Oct. 22	6.27	0.87	1.01	1.15	1.29	1.55	1.35	1.19	1.07	0.98	3.63
Oct. 23	6.27				1.02						6.02
Oct. 26	6.27	0.79	0.89	1.06	1.30		1.28	1.12	0.98	0.90	3.99
Means		0.79	0.92	1.04	1.15	1.42	1.23	1.05	1.00	0.90	
Departures		+0.04	+0.03	+0.09	+0.03	+0.01	+0.11	+0.11	+0.19	+0.18	
Madison, Wis.											
Oct. 1	9.83		0.92	1.03	1.21	1.44					7.29
Oct. 2	9.83			0.81	0.97	1.26					13.13
Oct. 5	7.87						1.10				7.87
Oct. 9	6.27		0.96	1.03	1.28	1.48	1.24				7.29
Oct. 16	6.76	0.85	0.98	1.08	1.23	1.46	1.31				6.02
Oct. 17	4.95		1.11	1.22	1.38						4.75
Oct. 19	5.36						1.17				7.57
Oct. 20	7.04		0.62	0.84	1.06	1.28	1.03				8.81
Oct. 21	8.18				0.92		1.04				9.83
Oct. 24	12.24				1.31						7.29
Oct. 28	5.36	0.63	0.83	1.09	1.31						4.17
Means		(0.74)	0.90	1.01	1.19	1.38	1.15				
Departures		−0.03	−0.01	−0.03	±0.00	−0.02	−0.04				
Lincoln, Nebr.											
Oct. 2	9.83	0.53	0.62				1.06				10.21
Oct. 4	12.24					1.42	1.19	0.98	0.85	0.74	12.24
Oct. 14	7.87	0.76		1.05							7.57
Oct. 15	7.29							1.15	1.04	0.95	8.81
Oct. 16	4.57	0.95	1.04	1.15	1.38			1.19	1.05	0.96	5.36
Oct. 17	5.79	0.47	0.70	0.90	1.27		1.31	1.18	1.03	0.93	6.02
Oct. 18	7.29						1.22	1.06	0.91	0.80	7.04
Oct. 19	9.47	0.88	0.97	1.10	1.21						11.38
Oct. 22	7.04	0.73	0.94	1.09	1.20		1.30	1.03			8.48
Oct. 23	11.81						1.19	1.07	0.91	0.80	10.21
Oct. 24	8.23							1.10	0.93	0.85	7.29
Oct. 27	3.30	0.85	0.98	1.10	1.32		1.28	1.16	1.02	0.94	4.57
Oct. 28	4.37		1.03	1.19	1.32						3.81
Means		0.74	0.90	1.08	1.28		1.22	1.10	0.97	0.87	
Departures		−0.11	−0.04	−0.02	±0.00		−0.03	+0.02	+0.02	+0.03	

[1] Extrapolated.

TABLE 2.—*Total solar radiation (direct+diffuse) received on a horizontal surface*

[Gram-calories per square centimeter]

AVERAGE DAILY TOTALS

Week beginning—	Washington	Madison	Lincoln	Chicago	New York	Twin Falls	Pittsburgh	Gainesville	Fresno	La Jolla	Miami	Fairbanks
1931	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.
Oct. 1	303	280	333	310	273	394	276		445	266	474	28
Oct. 8	295	210	272	172	299	394	187		428		390	25
Oct. 15	284	290	343	292	265	338	211		378		335	28
Oct. 22	271	187	329	201	276	200	190		383		462	25
	DEPARTURES FROM WEEKLY NORMLS											
Oct. 1	−26	+11	+10	+97	+14	−8	+25		+27	−75		
Oct. 8	−8	−34	−27	−22	+57	+8	−25		+34			
Oct. 15	+2	+65	+40	+114	+49	−42	+14		+12			
Oct. 22	+1	−18	+52	+41	+82	−136	+16		+51			
Accumulated departures on Oct. 28, 1931	−688	+3,311	+2,177	+1,827	+1,890	+4,822	−1,401		+1,267			

POSITIONS AND AREAS OF SUN SPOTS

[Communicated by Capt. J. F. Hellweg, Superintendent United States Naval Observatory. Data furnished by Naval Observatory, in cooperation with Harvard, Yerkes, Perkins, and Mount Wilson observatories. The differences of longitude are measured from central meridian, positive west. The north latitudes are plus. Areas are corrected for foreshortening and are expressed in millionths of sun's visible hemisphere. The total area, including spots and groups, is given for each day in the last column]

Date	Eastern standard civil time		Heliographic Diff. long.	Heliographic Longitude	Heliographic Latitude	Area Spot	Area Group	Total area for each day
1931	h	m	°	°	°			
Oct. 1 (Naval Observatory)	11	55	−40.0	309.9	+19.0		185	
			−30.5	319.4	+19.5	31		216
Oct. 2 (Naval Observatory)	10	40	−28.0	309.3	+19.0		154	
			−18.5	318.8	+19.0	25		179
Oct. 3 (Naval Observatory)	10	33	−14.0	310.2	+19.0	46		
			−5.0	319.2	+19.5	15		61
Oct. 4 (Naval Observatory)	10	41	−68.0	243.0	−9.0	62		
			−1.0	310.0	+19.0	46		
			+8.0	319.0	+20.0	6		114
Oct. 5 (Naval Observatory)	10	46	−51.0	246.7	−9.5	31		
			+12.0	309.7	+18.0	46		77
Oct. 6 (Naval Observatory)	10	48	−38.0	246.5	−10.0	15		
			+26.5	311.0	+17.0	31		46
Oct. 7 (Naval Observatory)	11	26	+40.0	311.0	+18.0	15		15
Oct. 8 (Naval Observatory)	11	20		No spots				
Oct. 9 (Naval Observatory)	10	38		No spots				
Oct. 10 (Naval Observatory)	10	37		No spots				
Oct. 11 (Naval Observatory)	10	41		No spots				
Oct. 12 (Naval Observatory)	10	48		No spots				
Oct. 13 (Naval Observatory)	10	40		No spots				
Oct. 14 (Mount Wilson)	14	15	+37.0	214.1	+1.0		10	10
Oct. 15 (Naval Observatory)	10	44		No spots				
Oct. 16 (Naval Observatory)	10	29		No spots				
Oct. 17 (Naval Observatory)	10	44		No spots				
Oct. 18 (Naval Observatory)	10	55		No spots				
Oct. 19 (Naval Observatory)	10	50	−77.0	36.0	−15.0	93		93
Oct. 20 (Naval Observatory)	10	35	−62.0	37.9	−15.0	93		93
Oct. 21 (Naval Observatory)	10	32	−50.0	36.8	−15.0	154		154
Oct. 22 (Naval Observatory)	11	5	−37.0	36.3	−16.0	154		154
Oct. 23 (Naval Observatory)	11	5	−23.5	36.6	−15.5	154		154
Oct. 24 (Naval Observatory)	10	39	−11.0	36.2	−16.0	123		123
Oct. 25 (Naval Observatory)	10	41	+2.0	35.9	−16.0	93		93
Oct. 26 (Naval Observatory)	10	35	+15.0	35.8	−16.0	123		123
Oct. 27 (Naval Observatory)	10	26	+28.0	35.7	−16.0	93		93
Oct. 28 (Mount Wilson)	11	40	+43.0	36.8	−15.5		121	121
Oct. 29 (Naval Observatory)	10	38	+56.5	37.7	−16.5	62		62
Oct. 30 (Naval Observatory)	10	34	+70.0	38.1	−17.0	62		62
Oct. 31 (Naval Observatory)	10	40		No spots				
Mean daily area for October								66

PROVISIONAL SUN-SPOT RELATIVE NUMBERS FOR OCTOBER, 1931

(Data dependent alone on observations at Zurich and its station at Arosa)

[Data furnished through the courtesy of Prof. W. Brunner, University of Zurich, Switzerland]

October, 1931	Relative numbers	October, 1931	Relative numbers	October, 1931	Relative numbers
1	10	11	7	21	10
2	21	12	0	22	9
3	14	13	Mc 8	23	24
4	a 18	14	9	24	18
5	15	15	8	25	
6	15	16	0	26	
7	7	17	0	27	11
8	8	18	0	28	10
9	7	19	d 8	29	9
10	0	20	8	30	
				31	Wc 18

Mean: 28 days=9.7.

a=Passage of an average-sized group through the central meridian.
c=New formation of a center of activity: E, on the eastern part of the sun's disk; W, on the western part; M, in the central zone.
d=Entrance of a large or average-sized center of activity on the east limb.

AEROLOGICAL OBSERVATIONS

[The Aerological Division, W. R. GREGG, in charge]

By L. T. SAMUELS

Free-air temperatures were moderately above normal at practically all levels and stations. (Table 1.) The greatest departures (between 3° and 4°) from the normal occurred at Ellendale and Omaha. Free-air relative humidities were mostly above normal at Chicago, Cleveland, and Dallas and below normal at the other stations. The greatest negative departures (−15 per cent) occurred at the 1,000 and 2,000-meter levels at Washington.

At the 1,000-meter level the resultant wind velocities were appreciably above normal at most stations, except along the Pacific Coast where they were close to normal. (Table 2.) Resultant directions were near normal at practically all stations.

At the 4,000-meter level the resultant velocities exceeded the normals at most of the northern stations. The greatest departures from the normal directions occurred at the southern stations. The normal northerly component was replaced by a westerly one over the northern Gulf region, while at Key West, the resultant direction was easterly instead of the normal westerly.

In Table 3 are shown the average and extreme heights attained and the number of flights made during the month.

TABLE 1.—*Mean free-air temperatures and humidities obtained by airplanes (or kites) during October, 1931*

TEMPERATURE (°C.)

Altitude (meters) m. s. l.	Chicago, Ill.[1] (190 meters)	Cleveland, Ohio[1] (245 meters)	Dallas, Tex.[1] (149 meters)	Due West, S. C.[1] (217 meters)	Ellendale, N. Dak.[2] (444 meters)	Hampton Roads, Va.[3] (2 meters)	Omaha, Nebr.[1] (299 meters)	Pensacola, Fla.[3] (2 meters)	San Diego, Calif.[3] (9 meters)	Washington, D. C.[3] (2 meters)
Surface	11.1	10.5	17.8	15.8	9.2	16.5	11.2	20.6	20.9	12.7
500	12.0	11.6	19.4	15.9	9.5	16.6	11.8	18.9	17.7	13.9
1,000	11.1	11.2	18.8	13.6	10.3	14.3	12.2	17.2	16.2	12.6
1,500	8.8	8.5	16.1	11.0	8.2		10.7			
2,000	6.6	6.2	13.6	8.8	6.2	9.7	8.5	12.8	12.5	9.1
2,500	4.0	4.0	11.3	6.2	3.7		6.2			
3,000	1.3	1.6	8.6	4.0	0.7	4.3	3.3	8.1	7.3	3.9
4,000	−4.3	−3.5	2.5	−0.7	−4.8		−2.9			1.3
5,000	−9.8	−8.7	−3.1	−7.1	−11.2		−9.4			
6,000		−14.2					−16.6			

RELATIVE HUMIDITY (PER CENT)

Altitude (meters) m. s. l.	Chicago, Ill.	Cleveland, Ohio	Dallas, Tex.	Due West, S. C.	Ellendale, N. Dak.	Hampton Roads, Va.	Omaha, Nebr.	Pensacola, Fla.	San Diego, Calif.	Washington, D. C.
Surface	83	81	83	70	71	80	83	81	65	78
500	74	73	71	61	68	65	76	76	65	60
1,000	67	66	63	58	55	63	64	74	57	52
1,500	61	64	60	54	51		58			
2,000	55	56	56	50	45	48	53	59	44	48
2,500	51	50	50	48	45		48			
3,000	51	47	45	37	48	32	50	49	36	43
4,000	49	42	40	33	47		45			36
5,000	38	41	32	32	59		43			
6,000		43					43			

[1] Airplanes (Weather Bureau). [2] Kites. [3] Airplanes (Navy).

TABLE 2.—*Free-air resultant winds (meters per second) based on pilot balloon observations made near 7 a. m. (E. S. T.) during October, 1931*

Altitude (meters) m. s. l.	Albuquerque, N. Mex. (1,528 meters) Direction	Velocity	Brownsville, Tex. (12 meters) Direction	Velocity	Burlington, Vt. (132 meters) Direction	Velocity	Cheyenne, Wyo. (1,873 meters) Direction	Velocity	Chicago, Ill. (198 meters) Direction	Velocity	Cleveland, Ohio (245 meters) Direction	Velocity	Dallas, Tex. (154 meters) Direction	Velocity	Due West, S. C. (217 meters) Direction	Velocity	Ellendale, N. Dak. (444 meters) Direction	Velocity	Havre, Mont. (762 meters) Direction	Velocity	Jacksonville, Fla. (14 meters) Direction	Velocity	Key West, Fla. (11 meters) Direction	Velocity
	°		°		°		°		°		°		°		°		°		°		°		°	
Surface	N 45 E	0.9	N 83 E	0.5	S 13 W	1.9	N 77 W	4.2	S 50 W	2.5	S 20 W	2.1	S 31 E	1.7	N 7 W	0.3	N 65 W	2.7	S 79 W	2.4	N 8 E	1.6	N 58 E	2.7
500			S 43 E	5.0	S 49 W	4.8			S 62 W	7.4	S 59 W	5.5	S 1 W	7.0	N 60 W	1.5	N 68 W	3.3			N 55 E	4.4	N 79 E	7.2
1,000			S 39 E	5.2	N 81 W	6.1			S 79 W	6.9	S 88 W	6.8	S 17 W	7.2	N 31 W	1.1	N 65 W	5.4	S 84 W	5.7	N 75 E	2.3	S 89 E	.06
1,500			S 48 E	4.2	N 73 W	8.5			N 86 W	7.5	S 88 W	7.2	S 43 W	5.0	N 75 W	1.5	N 89 W	4.9	N 77 W	7.9	S 14 E	0.5	S 78 E	4.3
2,000	W	0.6	S 49 E	2.8	N 83 W	8.6	N 86 W	6.4	N 89 W	9.1	S 87 W	8.0	S 79 W	2.9	N 73 W	2.5	S 78 W	5.7	N 80 W	7.7	S 66 W	1.9	S 83 E	3.2
2,500	S 67 W	3.0	S 59 E	1.3	N 81 W	8.1	N 74 W	9.2	W	8.0	W	9.4	N 77 W	2.9	N 72 W	3.7	S 80 W	6.6	N 75 W	7.8	S 69 W	1.7	S 82 E	4.1
3,000	S 76 W	5.4	N 37 E	0.7	N 78 W	7.7	N 65 W	9.9			N 83 W	10.1	S 75 W	1.9	N 68 W	4.4	S 75 W	8.0	N 80 W	7.6	N 55 W	1.2	N 85 E	3.2
4,000	N 84 W	9.4	N 34 W	2.8	N 54 W	9.3	N 64 W	9.3			N 83 W	10.1	N 14 E	0.5	N 58 W	4.0	S 77 W	12.7	S 89 W	7.9	S 78 W	4.7	N 70 E	2.2
5,000	N 77 W	9.7	N 41 W	1.8			S 81 W	10.1							N 71 W	5.9							N 54 E	2.1

Altitude (meters) m. s. l.	Los Angeles, Calif. (127 meters) Direction	Velocity	Medford, Oreg. (410 meters) Direction	Velocity	Memphis, Tenn. (125 meters) Direction	Velocity	New Orleans, La. (25 meters) Direction	Velocity	Oakland, Calif. (8 meters) Direction	Velocity	Oklahoma, City, Okla. (392 meters) Direction	Velocity	Omaha, Nebr. (299 meters) Direction	Velocity	Phoenix, Ariz. (356 meters) Direction	Velocity	Salt Lake City, Utah (1,294meters) Direction	Velocity	Sault Ste. Marie, Mich. (198 meters) Direction	Velocity	Seattle, Wash. (14 meters) Direction	Velocity	Washington, D. C. (10 meters) Direction	Velocity
	°		°		°		°		°		°		°		°		°		°		°		°	
Surface	N 77 E	0.3	S 6 E	0.4	S 1 E	1.1	N 63 E	1.3	S 17 E	1.0	S 5 E	1.6	S 60 W	0.3	S 69 E	1.8	S 30 E	2.7	N 44 E	0.3	S 35 E	1.4	N 49 W	0.7
500	S 88 E	0.6	S 89 W	0.6	S 36 W	4.6	S 74 E	4.5	N 17 W	0.7	S 1 W	4.2	S 59 W	2.1	S 72 E	1.4			S 68 W	2.9	S 24 W	3.0	N 72 W	5.2
1,000	S 87 E	0.3	S 49 W	0.5	S 45 W	4.2	S 64 E	2.9	N 13 E	1.2	S 40 W	7.0	S 69 W	5.4	S 78 E	1.0			N 80 W	6.9	S 25 W	3.2	N 68 W	5.6
1,500	N 68 W	1.0	S 4 W	1.1	S 59 W	3.2	S 62 E	1.7	S 82 E	0.4	S 70 W	6.2	S 83 W	7.4	S 5 E	1.5	S 16 E	3.7	N 79 W	8.4	S 37 W	4.0	N 61 W	7.2
2,000	N 71 W	1.0	S 46 W	2.6	S 70 W	2.6	N 32 W	0.6	S 31 E	0.7	N 89 W	5.2	N 86 W	7.5	S 15 W	3.3	S 4 W	3.5	N 74 W	10.0	S 40 W	3.2	N 70 W	8.0
2,500	S 68 W	1.7	S 62 W	2.5	N 82 W	1.5	N 21 W	2.3	N 4 E	0.9	N 77 W	4.5	N 85 W	8.1	S 32 W	5.2	S 41 W	2.5	N 70 W	11.0	S 21 W	2.5	N 70 W	9.8
3,000	S 81 W	2.0	S 67 W	2.9			N 66 W	4.1	N 54 W	3.0	N 57 W	5.8	N 85 W	7.4	S 45 W	6.3	S 58 W	4.1	N 80 W	11.2	N 32 E	1.7	N 75 W	9.9
4,000			N 84 W	4.9			S 86 W	6.0	N 66 W	1.6	N 40 W	4.2			S 55 W	12.7	S 68 W	5.9						
5,000			N 70 W	4.0			S 78 W	8.1									N 82 W	9.0						

TABLE 3.—*Observations by means of airplanes, kites, captive and limited-height sounding balloons during October, 1931*

	Dallas, Tex.[1]	Due West, S. C.	Ellendale, N. Dak.	Chicago, Ill.[1]	Cleveland, Ohio[1]	Omaha, Nebr.[1]
Mean altitudes, meters, m. s. l., reached during month	5,416	3,010	3,493	4,775	5,742	6,317
Maximum altitude, meters, m. s. l., reached	5,763	[2] 5,477	[3] 5,682	5,284	6,329	6,712
Number of flights made	31	31	27	31	31	32
Number of days on which flights were made	31	31	26	31	31	31

[1] Airplanes. [2] Limited-height sounding balloon. Kite.

WEATHER IN THE UNITED STATES

[The Climatological Division, OLIVER L. FASSIG, in Charge]

THE WEATHER ELEMENTS

By M. C. BENNETT

The month of October, as a whole, was warmer than normal in all sections of the country except a small area along the Pacific coast. The warmest weather occurred between the Appalachian and Rocky Mountains where the average for the month was generally from 4° to 7° above the normal. In large portions of the country where killing frost or freezing temperature almost invariably occurs before the end of October, this month ended without such occurrence, and the same was true of snowfall.

The precipitation during the month was scanty in most sections. A rather large area extending from the central portion of Indiana, Illinois, and Missouri northward received more than normal, some stations reporting one and one-half times the usual amount for October. The north Pacific and central Rocky Mountain areas also received rather generous falls, while in much of the east and south, except locally, the month was dry, many stations receiving less than 25 per cent of the normal. The far Southwest from New Mexico to the Pacific likewise received only about 25 per cent of the monthly average.

TEMPERATURE

October temperatures were decidedly like those of the September which had just preceded. Again only portions of the Pacific States averaged cooler than normal, and those portions but slightly. Most of the country, especially between the Rocky Mountains and the upper Lakes and lower Mississippi River, was decidedly warmer than normal. Warm weather prevailed nearly everywhere during most of the opening decade, notably from the middle and northern Plains to the upper Lakes. About the close of this decade cooler weather reached the far Northwest and the first part of the second decade was colder than normal in most northern and far-Western districts. The latter part of the second decade was featured by several comparatively cool days from the upper Mississippi Valley eastward and southeastward. Meantime warmth had prevailed in the greater part of the country, especially the Southwest.

The final decade was remarkable for high temperatures practically everywhere east of the Rocky Mountains until about the 28th, when cold weather reached the northern portions of the Plains and Rocky Mountain regions, whence it advanced southeastward so that the month closed with comparatively low temperatures prevailing in the central valleys and the Gulf States.

As a whole the month averaged slightly colder than normal in parts of the Pacific States, but elsewhere warmer. In much of Texas and the southern Plains it was the warmest October of record, and usually between the Rocky and Appalachian ranges the average excess was 4° to 7°. In the North Atlantic States the excess was but about 3° and near the south Atlantic coast less than 2°.

A temperature of 105° was noted in western Texas on the 6th. In most States the highest readings reported were between 90° and 100°, but in a few States, chiefly along the northern boundary, they were from 90° to 85° or slightly less. In nearly all States the highest readings occurred during the first decade.

The lowest reading reported was 7° below zero at a high station in Colorado on the 30th. Most States of the western half noted readings lower than 20°, also most northern border States to eastward, and some points in the middle and southern Appalachians. In nearly all States of the Ohio and Mississippi Valleys and in parts of the Southeast there were no readings lower than 25°. From the upper Mississippi Valley eastward and southeastward the lowest marks occurred chiefly during the middle decade, particularly about the 19th, but from the Plateau to the Plains and in the lower Mississippi Valley they usually occurred just before the month ended.

PRECIPITATION

As in September, the rainfall of October, 1931, was plentiful in much of the north-central portion and usually in the middle Rocky Mountain area, while it was very scanty in the Southeast and generally somewhat less than normal in the North and Middle Atlantic States, the Plains region, and the middle and northwestern Plateau area.

The first three weeks were decidedly dry in the Southeast, save southern Florida and a few other limited areas. Some portions of the Plains and most of the middle and upper Mississippi Valley and the western part of the Lake region had important rainfall during the second week of the month.

The final decade brought the most important rainfall of the month. There was much rain in the far Northwest, and in Wyoming and adjacent areas; likewise most districts from the Dakotas eastward to the north Atlantic coast and considerable parts of the Ohio and lower Mississippi Valleys and the near Southwest had moderate to liberal rainfall.

Only about one-third of the States had rainfall greater than normal for October, and in these the amounts were only moderately large. Much of the north-central portion of the country received somewhat more than normal, Illinois and Indiana averaging almost 4 inches, or an excess of over one-third the normal amounts. Smaller departures above normal were noted in the Pacific Northwest and a few other areas. The eastern and central portions of Oklahoma, with much of northern Texas and western Arkansas, received a considerable excess, as did some parts of Florida and southeastern Louisiana.

In the entire country the greatest amount for the month so far reported was 15.27 inches, at a station in western Washington. East of the Pacific States the greatest amount was 13.44 inches, at Burrwood, La.

From Pennsylvania southward there was a notable shortage in the Atlantic States, South Carolina receiving but four-fifths of an inch, on the average, or but about one-quarter of normal. At Charleston this was the sixteenth consecutive month to bring less than normal rainfall. Most of the East Gulf States, the lower Mississippi and upper Ohio Valleys, and southeastern and central Texas measured far less rain than normal; and there was a decided shortage in the greater part of the Rio Grande Valley, the western Plains, Montana, and the northern and western Plateau area.

SNOWFALL

The snowfall was decidedly light compared with the average amounts for October. Particularly from the central part of the Lake region westward over northern districts almost to the Rocky Mountains there was either no snow or merely negligible amounts, the greater part of the Missouri Valley reporting a few flurries during the final week. From northern New York southwestward to the central Appalachians there was a little snow just after the middle of the month.

From the Rocky Mountain States westward to beyond the Cascade-Sierra crest there was snowfall over considerable areas, though usually only at the higher elevations. This occurred almost wholly during the last fortnight of the month, and was generally of small amount, though there was a monthly fall of 52 inches at Mount Baker Lodge, in Washington.

SUNSHINE AND RELATIVE HUMIDITY

More than the usual amount of sunshine was received over much of the Atlantic Coast States, the upper Mississippi and upper Missouri Valleys and portions of Oklahoma, northern Texas, and southern New Mexico. Less than the normal amount was received in the upper Ohio, central Mississippi, and lower Missouri Valleys. Elsewhere it was generally near the average.

The relative humidity was above the normal in much of the Ohio, the central and upper Mississippi, and lower Missouri Valleys, in portions of the central Rocky Mountains and southern Plateau regions and locally in central Texas and on the Gulf coast. Elsewhere it was generally below the average, but in most sections the departures therefrom were small.

SEVERE LOCAL STORMS, OCTOBER, 1931

The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A revised list of tornadoes will appear in the Annual Report of the Chief of Bureau]

Place	Date	Time	Width of path (yards)[1]	Loss of life	Value of property destroyed	Character of storm	Remarks	Authority
Crawford, Fremont, and Madison Counties, Iowa.	6					Rain and flood	Lowlands inundated; considerable damage to crops, dirt roads, and sewers.	Official U. S. Weather Bureau.
Seneca and Crawford Counties, Ohio.	6					Floods	Crops, roads, and bridges damaged	Do.
Marshall County, Iowa	7	12:15 a. m.			$2,300	Wind	Crops, windmills, and garages damaged	Do.
Rotan (near), Tex.	7	4 p. m.	1,760		500	Tornado	50 bales of cotton destroyed; 2 persons injured	Do.
Terre Haute (near), Ind.	7	5:53 p. m.			16,000	Electrical	Dwelling burned and paper mill damaged by lightning.	Do.
Ames, Iowa	7	P. m.			52,505	do	Cattle barn at Iowa State College destroyed	Do.
Fort Mills, S. C.	9	6 p. m.	1,300		4,000	Small tornado	Crops and farm buildings damaged; path 1 mile long.	Do.
Honea Path (near) to Due West (near), S. C.	9	9 p. m.	1,320		6,000	Hail	Much cottonseed destroyed; 150 bales of cotton damaged; path 12 miles long.	Do.
Gramling, S. C.	9	P. m.			2,000	Thunderstorm	Schoolhouse damaged by lightning	Do.
Shelby County, Iowa	10	4:30-5 p. m.			25,000	Rain, hail, and wind.	Glass in buildings and greenhouses broken; poultry killed; trees damaged; path 10 miles long.	Do.
Norton, Phillips, and Sheridan Counties, Kans.	10	5:30-7 p. m.	20 mi.			Hail and wind	Corn damaged 90 per cent in places; small farm buildings, implements, and windmills damaged; 2 persons injured; path, 65 miles long.	Do.
Marshall County, Iowa	10	7-8 p. m.				Rain, hail, wind, and electrical.	Considerable damage to roofs, farm buildings, and trees; poultry killed; electric, power, and telephone services crippled.	Do.
Cloud, Jewell, Republic, and Washington Counties, Kans.	10	8 p. m.	10 mi.		15,000	Violent wind	Damage chiefly to farm buildings, livestock, and telephone lines; path, 40 miles long.	Do.
Bureau, Carroll, and La Salle Counties, Ill.	10	P. m.				Rain and flood	Pavements damaged; railroad beds washed out; basements flooded; crops hurt; some loss of livestock.	Do.
Cass and Pottawatamie Counties, Iowa.	10	do				Wind and rain	Farm buildings, windmills, and trees damaged; several buildings moved on foundations; 1 person injured.	Do.
Clinton and Jackson Counties, Iowa.	10	do				Rain and flood	Lowlands inundated; minor railroad washouts; 10 small bridges wrecked; basements flooded.	Do.
Fremont County, Iowa	11	5:50-10:30 p. m.				Wind	Trees, roofs, and outbuildings damaged	Do.
Colby (near), Kans.	11	7 p. m.				Hail	Chief damage to corn and other feed crops	Do.
Shreveport, La. (7 miles southeast).	15	1:50 p. m.			$500	Tornado	Character of damage not reported; path 3 miles long.	Do.
Gouverneur (near), N. Y.	25				3,000	Thunderstorm	Farmhouse struck by lightning and burned	Do.
Quincy, Ill.	25	A. m.			1,500	Rain and flood	Basements flooded; sewers and sidewalks damaged; traffic delayed.	Do.
Wyoming (eastern half)	26-29					Wind	Poles blown down; many miles of fences damaged or destroyed; store windows broken in Cheyenne.	Do.
Somerset (near), Tex.	29	4:30 p. m.	1,760		75,000	Tornado	75 oil derricks damaged; minor damage to other property.	Do.

[1] "Mi." signifies miles instead of yards.

RIVERS AND FLOODS

By RICHMOND T. ZOCH

[River and Flood Division, Montrose W. Hayes in charge]

Heavy local rains in Crawford County, Ohio, on the 6th, caused creeks to overflow, doing damage estimated at $1,200.

The only river flood was in the Grand, in northcentral Missouri. It was of very minor importance and the attendant damage was estimated at only $100.

Table of flood stages in October, 1931

River and station	Flood stage	Above flood stages—dates		Crest	
		From—	To—	Stage	Date
MISSISSIPPI SYSTEM					
Missouri Basin					
Grand:	*Feet*			*Feet*	
Gallatin, Mo.	20	12	13	24.1	12
Chillicothe, Mo.	18	12	14	21.2	13

WEATHER OF THE ATLANTIC AND PACIFIC OCEANS

[By the Marine Division, W. F. McDONALD in charge]

NORTH ATLANTIC OCEAN

By W. F. McDONALD

The pressure situation.—The first half of October, 1931, over the North Atlantic Ocean and adjacent continental areas was characterized by a pressure distribution which was quite stable in its large outlines. An extensive but moderate HIGH dominated the Atlantic between the United States and Spain, but a series of LOWS maintained a pressure trough from Labrador to northern Scandinavia during the first two weeks of the month. In general the track of the centers of individual LOWS was similar to that followed by the disturbances of the latter part of September and including that period there was about five weeks of remarkably persistent pressure distribution.

In the middle of October, however, there was a decided change in the pressure situation beginning with the development of a minor tropical disturbance about the 13th over the Bahama group. Immediately thereafter, a LOW appeared suddenly in mid-Atlantic near the Azores, and an extensive trough formed simultaneously, extending from the Florida Straits northward to Hudson Strait. This developed into a deep LOW off the middle Atlantic coast in the next few days.

After the 16th, a succession of well-developed low-pressure areas crossed the Atlantic between latitudes 30° and 50° N., with the result that the normal ocean high-pressure area was disrupted. During the last half of the month, HIGHS were more transitory, and the only stable high-pressure conditions prevailed over the far northern portion of the ocean and along the European coast.

The resultant barometric averages for the month as a whole (see Table 1) revealed again, as in the previous month, above-normal pressures in the northeastern Atlantic, but central in this case over the British Isles. There was a deficiency from the Azores to New England and also from the Azores southwestward over the Caribbean Sea, with a slight excess of pressure over the Gulf of Mexico.

Gales and disturbances.—Gales were reported on the Atlantic on 22 days in October, and winds of gale force at some time in the month from nearly every part of the ocean north of a line from Turks Island to Lisbon. A few days at the opening and at the close of the month were comparatively quiet. Two to three day intervals on the 12–13th, 15–17th, 21–22d, and 26–28th, comprised the most widespread storminess, the 12–13th being perhaps the most disturbed period. On the latter dates, gales were encountered (well off the American coast) from latitude 30° northeastward to mid-Atlantic in latitude 60°. Winds of hurricane force were experienced on the 13th by the German ship *New York*, enroute westward near latitude 45° N., longitude 43° W. This was the highest wind reported during the month.

Gales of force 11 were reported on several dates from the main trans-Atlantic steamer route, and whole gales with some frequency between the 9th and 22d. Shipping was but slightly hampered, however, and no major damage to marine commerce has been reported, although several small ships were in distress, and the 100-ton motor ship *Canusa* (British) was lost near the Bahamas about the 15th.

Two barometric depressions, apparently weak tropical disturbances in origin, appeared over the region of the Bahamas, the first between the 12th and 15th and the second about a week later. The first development produced no high winds so far as reports in hand indicate, but the second caused moderate to fresh gales on the 20th and 22d as it moved northeastward into the middle-western part of the Atlantic.

The latter storm development appears to have been the major factor in producing the predominant cyclonic conditions of the last decade of October. Its progress at successive stages is shown in four charts (VIII to XI) dated at 2-day intervals during the life of the disturbance, beginning with October 22.

Fog.—There was some increase as compared with fogs in September, but fogginess was not seriously prevalent at any period in October. As usual, the most frequent reports of this condition came from the areas around the Grand Banks, but even there the prevalence was less than 25 per cent. A few scattered fogs were encountered well southward in the western Atlantic, towards Bermuda, and similar conditions in the eastern Atlantic as far southward as the offing of the Straits of Gibraltar.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure (sea level) at selected stations for the North Atlantic Ocean and its shores, October, 1931*

Stations	Average pressure	Departure	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Julianehaab, Greenland [1]	29.87		30.55	17th	29.10	13th.
Reykjavik, Iceland [1]	29.65	−0.03	30.68	20th	28.71	2d.
Lerwick, Shetland Isles [1]	29.85	+0.06	30.52	18th	29.25	8th.
Valentia, Ireland [1]	30.12	+0.21	30.62	14th	29.59	23d.
Lisbon, Portugal [1]	30.09	+0.07	30.38	2d	29.50	24th.
Madeira [1]	30.03	+0.05	30.25	11th	29.82	22d.
Horta, Azores [1]	29.98	−0.13	30.39	7th	29.27	22d.
Belle Isle, Newfoundland [1]	29.94	+0.07	30.36	12th	29.28	2d.
Halifax, Nova Scotia [1]	29.96	−0.08	30.34	1st	29.38	26th
Nantucket [2]	30.00	−0.05	30.41	13th	29.34	16th.
Hatteras [2]	30.11	+0.05	30.47	1st	29.64	16th.
Bermuda [1]	30.07	0.00	30.26	14th	29.76	16th.
Turks Island [1]	30.00	−0.05	30.08	30th	29.88	4th.
Key West [2]	29.97	+0.03	30.14	1st	29.81	17th.
New Orleans [2]	30.06	+0.03	30.30	1st	29.79	28th.
Cape Gracias [1]	29.83	−0.09	29.94	1st	29.76	18th.

[1] All data based on a. m. observations only, with departure computed from best available normals related to time of observation.
[2] Corrected 24-hour means, based on more than one observation daily.

OCEAN GALES AND STORMS, OCTOBER, 1931

Vessel	Voyage: From—	Voyage: To—	Position at time of lowest barometer: Latitude	Position at time of lowest barometer: Longitude	Gale began	Time of lowest barometer	Gale ended	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Direction and highest force of wind	Shifts of wind near time of lowest barometer
NORTH ATLANTIC OCEAN			° ′	° ′				Inches					
Makiki, Am. S. S.	Mobile	San Pedro	28 06 N	87 13 W	Oct. 1	8 p., 1	Oct. 2	30.09	NE	NE, 7	ENE	E, 8	E-NE-E.
Ala., Am. S. S.	Antwerp	Baltimore	42 18 N	65 00 W	do	Noon, 2	do	30.02	SW	SW, 8	SW	SW, 8	Steady.
Maravi, Pan. S. S.	Preston, Cuba.	Boston	29 35 N	73 06 W	Oct. 3	8 p., 3	Oct. 4	30.10	ENE	ENE, 8	E	ENE, 8	ENE-E.
Dresden, Ger. S. S.	Bremerhaven	New York	50 15 N	24 53 W	Oct. 5	5 p., 5	Oct. 8	29.70	WNW	WNW, 8	NW	WNW, 10	WNW-NW.
Maine, Dan. S. S.	Swansea	Montreal	53 34 N	23 26 W	do	4 a., 6	Oct. 7	29.50	SSW	W, —	WNW	W, 10	
Winnebago, Br. S. S.	River Tyne	Philadelphia	58 35 N	10 20 W	do	4 p., 6	Oct. 10	29.07	SW	SW, 7	SW	—, 9	SW-W.
Saco, Am. S. S.	Antwerp	Boston	48 56 N	32 27 W	Oct. 7	11 p., 7	do	29.70	SSW	SSW, 7	W	WNW, 9	
Tiger, Nor. S. S.	Bergen	Baton Rouge	58 56 N	15 00 W	Oct. 8	9 p., 9	Oct. 11	29.12	SW	WSW, 9	WSW	WSW, 11	S-SW-W.
Cameronia, Br. S. S.	New York	Glasgow	55 33 N	16 07 W	Oct. 10	Noon, 10	Oct. 10	29.81	SW	SW, 9	W	SW, 9	Steady.
Caraboba, Am. S. S.	do	La Guaira	24 15 N	67 10 W	Oct. 11	1 a., 11	Oct. 12	30.04	SE	SE, —	SE	—, 8	SE-S.
Milwaukee, Ger. S. S.	Cobh	New York	42 23 N	58 15 W	Oct. 12	8 a., 12	Oct. 13	29.66	SSE	W, 5	NW	WNW, 9	W-NW.
Sinaia, Fr. S. S.	Gibraltar	Providence	39 10 N	62 05 W	do	10 a., 12	do	29.77	SSW	WSW, 9	NW	—, 9	
W. C. Teagle, Am. S. S.	Baytown	New York	38 10 N	74 25 W	do	—, 12	Oct. 12		N	N, 8	N, 3	—, 8	
Tiger, Nor. S. S.	Bergen	Baton Rouge	56 01 N	31 50 W	Oct. 13	4 p., 13	Oct. 14	29.72	SSW	SSW, 10	SW	SSW, 10	SSW-SW.
New York, Ger. S. S.	Cherbourg	New York	45 20 N	43 00 W	do	—, 13	Oct. 13	29.21	SSE	SE, 12	W	SE, 12	
Excambion, Am. S. S.	New York	Gibraltar	38 00 N	13 20 W	Oct. 12	4 a., 14	Oct. 14	30.05	N	ENE, 8	NE	NE, 9	Steady.
City of Alton, Am. S. S.	Rotterdam	New York	50 15 N	29 10 W	do	4 a., 15	Oct. 15	29.83	NW	SW, 8	NW	S, 9	Do.
Maravi, Pan. S. S.	Boston	Preston, Cuba.	28 55 N	73 20 W	Oct. 15	5 p., 15	do	29.62	S	SW, 7	WNW	S, 8	S-SW-W.
Dresden, Ger. S. S.	New York	Bremerhaven	41 18 N	65 30 W	do	8 p., 16	Oct. 16	29.24	SE	S, 10	S	S, 10	
Greystoke Castle, Br. M. S.	Port Said	New York	37 26 N	58 18 W	do	7 a., 17	Oct. 17	29.69	ESE	S, —	W	SE, 9	SE-S.
Davisian, Br. S. S.	San Juan	Havre	41 40 N	34 57 W	do	4 p., 17	Oct. 18	29.26	NW	WSW, 6	ESE	S, 9	
Changuinola, Br. S. S.	Jamaica	Avonmouth	39 00 N	36 33 W	Oct. 17	4 a., 19	Oct. 19	29.40	NW	NNW, 6	NE	NNW, 8	NNW-N-NE.
El Almirante, Am. S. S.	New Orleans	New York	25 20 N	80 12 W	Oct. 19	8 p., 19	Oct. 20	29.86	NE	NE, 8	NE	NE, 8	Steady.
Davisian, Br. S. S.	San Juan	Havre	47 28 N	17 14 W	Oct. 20	Noon, 21	Oct. 21	29.39	E	ESE, 7	E	—, 9	E-ESE.
Davenport, Am. S. S.	Antwerp	Tampa	39 21 N	27 30 W	Oct. 21	8 p., 21	Oct. 23	29.21	S	S, 4	WSW	SSW, 9	W-SSW-WSW
Southern Prince, Br. M. S.	Rio de Janeiro.	New York	27 23 N	66 58 W	Oct. 20	5 a., 21	Oct. 21	29.47	S	W, 7	NNE	N, 9	W-NW-N.
West Chetac, Am. S. S.	St. Vincent	New Orleans	25 34 N	61 38 W	Oct. 21	4 p., 21	Oct. 22	29.65	SSW	SW, 8	N	—, 8	SW-W.
British Lantern, Br. S. S.	Port Arthur	Montreal	38 31 N	68 07 W	Oct. 22	4 p., 22	Oct. 24	29.91	NW	NW, 10	NNE	NW, 10	
West Totant, Am. S. S.	Manchester	New Orleans	30 00 N	53 25 W	Oct. 21	10 a., 22	Oct. 22	29.50	WSW	SW, 10	WNW	SW, 10	SW-NNW.
Dresden, Ger. S. S.	New York	Bremerhaven	51 48 N	25 18 W	do	8 a., 22	do	29.59	ENE	ENE, 10	ENE	ENE, 10	Steady.
Independence Hall, Am. S. S.	Bordeaux	New York	43 54 N	55 45 W	Oct. 22	9 p., 22	Oct. 24	29.62	NE	NE, 7	NE	NE, 9	Do.
New York, Ger. S. S.	New York	Cherbourg	43 18 N	48 00 W	do	Noon, 25	Oct. 25	29.12	NNW	NNW, 7	E	NE, 10	NNW-E.
Sundance, Am. S. S.	Hamburg	Jacksonville	42 50 N	62 54 W	Oct. 27	—, 27	Oct. 30	29.28	NW	WSW, —	SW	SW, 9	WSW-NW.
Norwegian, Br. S. S.	Liverpool	New Orleans	37 44 N	44 12 W	Oct. 28	Noon, 28	Oct. 29	29.74	SW	SW, 8	NW	—, 8	WSW-NW.
Lepanto, Br. S. S.	Hull	Boston	46 26 N	41 10 W	Oct. 29	9 a., 29	Oct. 30	29.47	W	W, 5	WNW	NW, 8	W-NW.
NORTH PACIFIC OCEAN													
Pres. Cleveland, Am. S. S.	Seattle	Yokohama	52 10 N	151 05 W	Oct. 6	8 p., 6	Oct. 7	29.98	S	SSW, 9	WSW	SSW, 9	S-SW-WSW.
Do	do	do	48 08 N	168 36 E	Oct. 8	2 a., 13	Oct. 14	29.40	SW	W, 9	W	W, 9	SE-W-NW.
Emp. of Asia, Can. S. S.	Yokohama	Vancouver	50 34 N	158 00 W	do	4 a., 9	Oct. 9	29.71	SW	WSW, 7	WSW	SW, 8	SW-WSW.
City of Victoria, Can. S. S.	Osaka	America	34 39 N	140 08E	Oct. 9	4 p., 10	Oct. 10	29.45	NE	N, 9	N	N, 9	
Achilles, Br. S. S.	Singapore	Hong Kong	[1]17 30 N	113 43 E	do	8.30 a., 10	Oct. 11			Calm		—, 12	
Wisconsin, Am. S. S.	Dairen	San Francisco	47 45 N	161 00 W	Oct. 10	10 p., 10	do	29.36	SSW	SSW, 8	WSW	SSW, 9	
Yokohama Maru, Jap. S. S.	Yokohama	Victoria	50 08 N	147 44 W	do	Noon, 11	do	29.26	SSW	SSW, 8	SW	SSW, 9	Steady.
Amalthus, Br. S. S.	Kobe	San Pedro	36 45 N	144 00 E	do	Mdt., 10	do	29.11	NE	NE, —	NW	N, 9	E-NE-N.
Victoria, Am. S. S.	Seattle	Nome	51 28 N	141 36 W	Oct. 11	6 a., 11	Oct. 14		S	S, 9	NNE	S, 9	
Golden Tide, Am. S. S.	Hong Kong	San Francisco	47 41 N	179 21 W	do	10 p., 16	Oct. 16	28.36	SSE	SW, 7	WNW	WNW, 11	
Alaska, Am. S. S.	Seattle	Seward	60 00 N	145 45 W	Oct. 12	1 a., 12	Oct. 12	29.13	E	E, 8		ENE, 8	E-ENE.
Golden Sun, Am. S. S.	San Francisco	Yokohama	44 29 N	164 25 E	do	Noon, 12	Oct. 13	29.54	SSW	SW, 7	WNW	NNW, 9	SW-W-NW.
Do	do	do	42 50 N	157 20 E	Oct. 14	7 a., 15	Oct. 15	29.00	S	NW, 10	NNW	NW, 10	SW-W-NW.
Pres. Cleveland, Am. S. S.	Victoria	do	44 25 N	155 59 E	do	12 p., 14	do	29.02	SW	E, 4	NW	NNW, 9	SE-E-NNW.
Pres. Jefferson, Am. S. S.	Yokohama	Victoria	48 17 N	175 10 E	Oct. 15	6 a., 16	Oct. 16	28.55	E	NNW, 7	NW	NW, 9	SSW-NNW.
Silvercypress, Br. M. S.	San Francisco	Yokohama	42 35 N	180 00	Oct. 16	Mdt.	do	29.19	SW	SSW, —	WNW	WSW, 9	S-WSW.
Sierra, Am. S. S.	do	Pago Pago	33 10 N	122 01 W	Oct. 17		Oct. 18	29.97	NW		NNW.	NW, 8	NW-NNW.
Golden Wall, Am. S. S.	Hong Kong	San Francisco	22 20 N	125 25 E	do	4 a., 18	do	29.69	NE	ENE, 8	ENE	NE, 8	ENE-E.
Winnipeg, Fr. S. S.	San Pedro	Portland	Arena	Point	Oct. 18	—, 18	Oct. 19	[2]29.78	NW	NW, 7	N	NNW, 8	
Golden Tide, Am. S. S.	Hong Kong	San Francisco	46 58 N	158 26 W	Oct. 19	8 a., 20	Oct. 20	29.81	SW	WSW, 9	WNW.	SW, 9	
Pres. Taft, Am. S. S.	Victoria	Yokohama	51 56 N	152 15 W	Oct. 20	8 p., 20	Oct. 22	28.87	S	WNW, 10	NW	WNW, 10	W-WNW-NW.
Melville Dollar, Am. S. S.	Everett	Shanghai	35 08 N	161 57 E	Oct. 21	4 a., 21	Oct. 21	29.80	SSW	SSW, 7	NNE	—, 9	
Pres. Taft, Am. S. S.	Victoria	Yokohama	50 59 N	178 16 W	Oct. 25	Noon, 25	Oct. 26	29.35	SSW	E, 8	NNW	E, 8	ESE-E-NNE.
Golden Wall, Am. S. S.	Hong Kong	San Francisco	36 30 N	148 20 E	Oct. 26	10 a., 27	Oct. 27	29.59	S	E, 7	N	N, 8	S-E-NE.
Melville Dollar, Am. S. S.	Everett	Shanghai	41 24 N	166 40 W	Oct. 27	Noon, 27	do	29.85	NW	NW, 9	NW	NW, 9	Steady.
Kentucky, Am. S. S.	Legaspi	San Francisco	43 14 N	142 25 W	Oct. 28	6 a., 28	Oct. 28	29.60	S	S, 8	SW	S, 8	S-SW.
Hakushika Maru, Jap. S. S.	Miike	Port Townsend.	44 06 N	160 02 E	Oct. 27	4 a., 28	do	[2]29.22	SE	SSE, 8	NW	SE, 10	SE-NE.
Do	do	do	46 03 N	171 40 E	Oct. 29	8 a., 30	Oct. 30	[2]20.22	SSE	W, 9	W	W, 10	WSW-W.
Victoria, Am. S. S.	Seattle	Nome	54 10 N	150 45 W	Oct. 28	Noon, 28	Oct. 31	28.94	E	SE, 9	SSW	SE, 9	SE-SSE.
Toba Maru, Jap. S. S.	Yokohama	San Francisco	45 00 N	145 00 W	Oct. 30	8 a., 31	do	29.47	WSW	W, —	WNW	W, 8	2 pts.
Melville Dollar, Am. S. S.	Everett	Shanghai	41 27 N	154 31 W	do	Noon, 30	do	29.49	W	W, 7	NW	—, 9	4 pts.
SOUTH PACIFIC OCEAN													
Tymeric, Br. S. S.	Newcastle	Corral, Chile	36 40 S	98 00 W	Oct. 3	Noon, 3	Oct. 4	29.40	N	NW, 8	W	N, 9	N-NW-W.
SOUTH ATLANTIC OCEAN													
Eskdalegate, Br. S. S.	River Tyne	Buenos Aires	29 49 S	48 00 W	Oct. 14	4 p., 14	Oct. 15	[2]29.96	SW	W, 9	W	W, 9	WSW-W.

[1] Vessel's position approximate.

[2] Barometer readings uncorrected.

NORTH PACIFIC OCEAN

By WILLIS E. HURD

Atmospheric pressure.—An inspection of Table 1 shows that the coastal section of the United States had practically normal atmospheric pressure for October, 1931, while the entire Aleutian region and Alaskan waters had pressure considerably below the normal for the month. It was here also somewhat lower than the normal even for midwinter. A decided downward trend of the barometer in northern waters began about the 10th, and thereafter until the end of the month a succession of deep LOWS crossed the upper steamship routes, the Bering Sea, and the Gulf of Alaska. The average center of the Aleutian LOW in October lay in the neighborhood of Kodiak, where the pressure for the month was 29.41 inches.

The North Pacific HIGH lay as usual off the California coast fluctuating somewhat, as LOWS pressed upon or penetrated into it, but maintaining its existence fairly intact throughout the month.

In Asiatic waters a succession of LOWS and typhoons rendered pressure conditions as usual very unstable.

The following table gives barometric data for several island and coast stations in west longitudes, including Point Barrow on the Arctic Ocean:

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level, North Pacific Ocean and adjacent waters, October, 1931, at selected stations*

Stations	Average pressure	Departure from normal	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Point Barrows [1] [2]	29.80	−0.13	30.30	27th [4]	29.34	17th.
Dutch Harbor [1] [3]	29.57	−0.08	30.18	1st [4]	28.52	16th.
St. Paul [1]	29.51	−0.12	30.14	18th	28.58	13th.
Kodiak [1]	29.41	−0.18	29.94	5th	28.60	21st.
Midway Island [1]	30.08	+0.05	30.22	18th	29.88	5th.
Honolulu [5]	29.99	−0.01	30.09	20th	29.84	10th.
Juneau [5]	29.75	−0.12	30.49	6th	28.90	31st.
Tatoosh Island [5] [6]	30.01	0.00	30.44	7th	29.14	21st.
San Francisco [5] [6]	30.02	+0.01	30.26	26th	29.66	18th.
San Diego [5] [6]	29.96	+0.01	30.09	15th	29.73	18th.

[1] P. m. observations in averages; a. m. and p. m. in extremes.
[2] For 29 days.
[3] For 30 days.
[4] And on other dates.
[5] A. m. and p. m. observations.
[6] Corrected to 24-hour mean.

Cyclones and gales.—Storminess on the North Pacific did not assume severe proportions as a rule until after the 10th of October. Prior to that date two typhoons originated in the Far East, and moderate cyclonic conditions prevailed over the northern waters, causing gales of force 8 to 9 over scattered areas from the central Aleutians eastward.

On the 11th the Aleutian cyclone spread out and deepened, with the result that local gales of force as high as 10 occurred near the Peninsula of Alaska, and of lesser force over a considerable surrounding region. On the 15th the most vigorous extratropical cyclone of the month lay over and to the southward of the western Aleutians. Since a typhoon was moving rapidly eastward from a position southeast of the Kuril Islands on the 14th its influence was in all probability a great factor in increasing the energy of the Aleutian cyclone central west of the one hundred and eightieth meridian, between 40° and 50° latitude, on the 15th. On this date the maximum reported strength of the gales had risen to force 11 near 47° N., 175° E., and pressure had fallen below 28.50 inches south of Atka, Aleutian Islands. On the 16th a radio report from the American steamship *Grays Harbor*, near 50° N., 175° W., indicated that the vessel was experiencing a northwest wind of hurricane velocity. The storm moved northeastward with diminishing intensity and by the 19th had largely entered the continent through Alaska.

This cyclone was quickly succeeded by another Aleutian storm which moved into south Alaskan waters and there remained from the 20th to 24th, with central pressures below 28.50 inches on the first two days and moderate to whole gales blowing north of the fiftieth parallel. Thenceforth to the end of October pulsations of the Aleutian LOW covered the Gulf of Alaska, accompanied by scattered gales of moderate to strong force, that were experienced from the 27th to 31st as far south as the fortieth parallel.

Moderate to fresh gales were reported off the central California coast on the 8th and 17th, associated with the activities at the rear of LOWS then central over Nevada. Another California coast gale was that of the 21st, on which date the Gulf of Alaska LOW extended almost to the latitude of San Francisco.

Over the western part of the North Pacific Ocean, between the Asiatic coast and 160° east longitude, such stormy weather as prevailed resulted from the continental cyclones that went seaward from northern Japan and Siberia, and from such tropical depressions and typhoons as occurred.

From the few reports of our marine observers, in lower Asiatic waters, in conjunction with the Tokyo Weather maps, the tracks of four October typhoons can be plotted. All originated in low latitudes between the Caroline and Philippine Islands, and two moved westward over or near Luzon into the China Sea. These two were the typhoons of October 6 to 11 and October 15 to 20. Little is known at this writing as to the actual violence of these storms, except that the earlier developed hurricane force on the 10th some 300 to 350 miles south of Hong Kong, as shown in the report of the British tanker *Achilles*. This vessel also during a period of five minutes beginning at 8.30 a. m., passed through the typhoon's region of central calm.

The two other typhoons, one of the 6th to 14th, and the other of the 20th to 27th, passed well into middle latitudes. The earlier recurved near 22° N., 127° E., crossed the Nansei Islands on the 12th and central Japan on the 13th, and with increased velocity of progression went seaward where it seems to have become a part of the prevalent Aleutian LOW. Thirty lives were reported lost in Japan as this storm passed. Fresh to strong gales attended its passage over the ocean on the 14th, after leaving Japan. The other typhoon did not go so far to the westward. It recurved toward northeast on the 24th near the twentieth parallel, near 133° east longitude, crossed the Ogasawara Islands on the 25th, and was last identified on the 27th near 42° N., 155° E.

No tropical cyclones occurred in Mexican west coast waters this month. And no northers of moment occurred in the Gulf of Tehuantepec until the 31st, when a moderate northwest gale was experienced there during the southward movement of a strong anticyclone over the United States.

Winds at Honolulu.—The prevailing wind direction at Honolulu was from the east, and the maximum velocity was 24 miles an hour from the northeast on the 21st.

Fog.—The production of fog lessened materially along the trans-Pacific routes, and thick weather from this source was of little moment even in northern waters.

Fog was general, however, for some distance east of the Kuril Islands on the 1st to 4th. It was only along the American coast that fog formed readily and frequently this month. Here between North Head and Point Arguello it formed on at least 12 to 15 days of the month. Off the west coast of Lower California it was reported on 7 days.

First nonstop flight across the Pacific.—On October 3 at 5.01 p. m. (E. S. T.) Clyde Pangborn and Hugh Herndon, American flyers, took off in a plane from Samoshiro Beach, near Tokyo, Japan, and landed at Wenatchee, Wash., at 10.14 a. m. (E. S. T.) on October 5, after a flight of 41 hours and 13 minutes, covering a distance of 4,877 miles.

The start was made under good weather conditions, with an anticyclone overlying Japan on the 3d. Southeast of the Kuril Islands, on the 3d and 4th, some fog seems to have been the only hazard confronting the early part of the trip. The Aleutian LOW was comparatively shallow and not stormy, but rather, seems to have given favoring winds over much of the north-central part of the ocean. Fine anticyclonic weather prevailed for a long distance westward from the American coast on the 5th. The weather hardly could have been more favorable for such a trip in October.

BUCKET OBSERVATIONS OF SEA-SURFACE TEMPERATURES

By GILES SLOCUM

STRAITS OF FLORIDA AND CARIBBEAN SEA

Table 1 shows the average temperatures for the Caribbean Sea and the Straits of Florida for October of each year from 1919 to 1930, inclusive, and Table 2 summarizes the temperatures for October, 1930, in the same areas. The chart shows the number of observations taken in October, 1930, within each 1-degree square and mean temperature data for subdivisions of the area considered.

The surface waters of the Caribbean average nearly as warm in October as in the warmest month of the year, September. From a mean temperature at, or near, the yearly maximum, the water cools at a rate somewhat more pronounced than is the rise in its temperature during September, but still at so slow a rate that, throughout the month, the sea retains the high surface temperature characteristic of the summer season.

Autumn conditions, however, are in evidence in the region of the Florida Straits. The temperature drops with comparative rapidity, usually approaching, by the end of October, the yearly mean for the area, while throughout the month the straits are cooler than the Caribbean, a winter characteristic.

October, 1930, was cooler than the 11-year October mean in the straits, and warmer than the mean in the Caribbean for the eighth consecutive month of 1930, with all four quarters of the month warmer than the 11-year mean for either September or October.

TABLE 1.—*Mean sea-surface temperatures in the Caribbean Sea and the straits of Florida for October, 1919–1930*

Year	Caribbean Sea		Straits of Florida	
	Number of observations	Mean (° F.)	Number of observations	Mean (° F.)
1919 [1]	92	82.2	29	81.8
1920	132	82.0	39	79.9
1921	252	82.1	74	82.0
1922	248	82.4	90	81.6
1923	290	81.6	108	81.1
1924	286	82.6	112	80.6
1925	389	82.5	121	82.8
1926	453	83.0	180	82.0
1927	558	83.4	179	81.8
1928	550	82.6	160	82.3
1929	623	82.5	201	80.1
1930	627	82.9	177	81.2
Mean (1920–1930)		82.5		81.4

[1] Not used in computations because of insufficient data available.

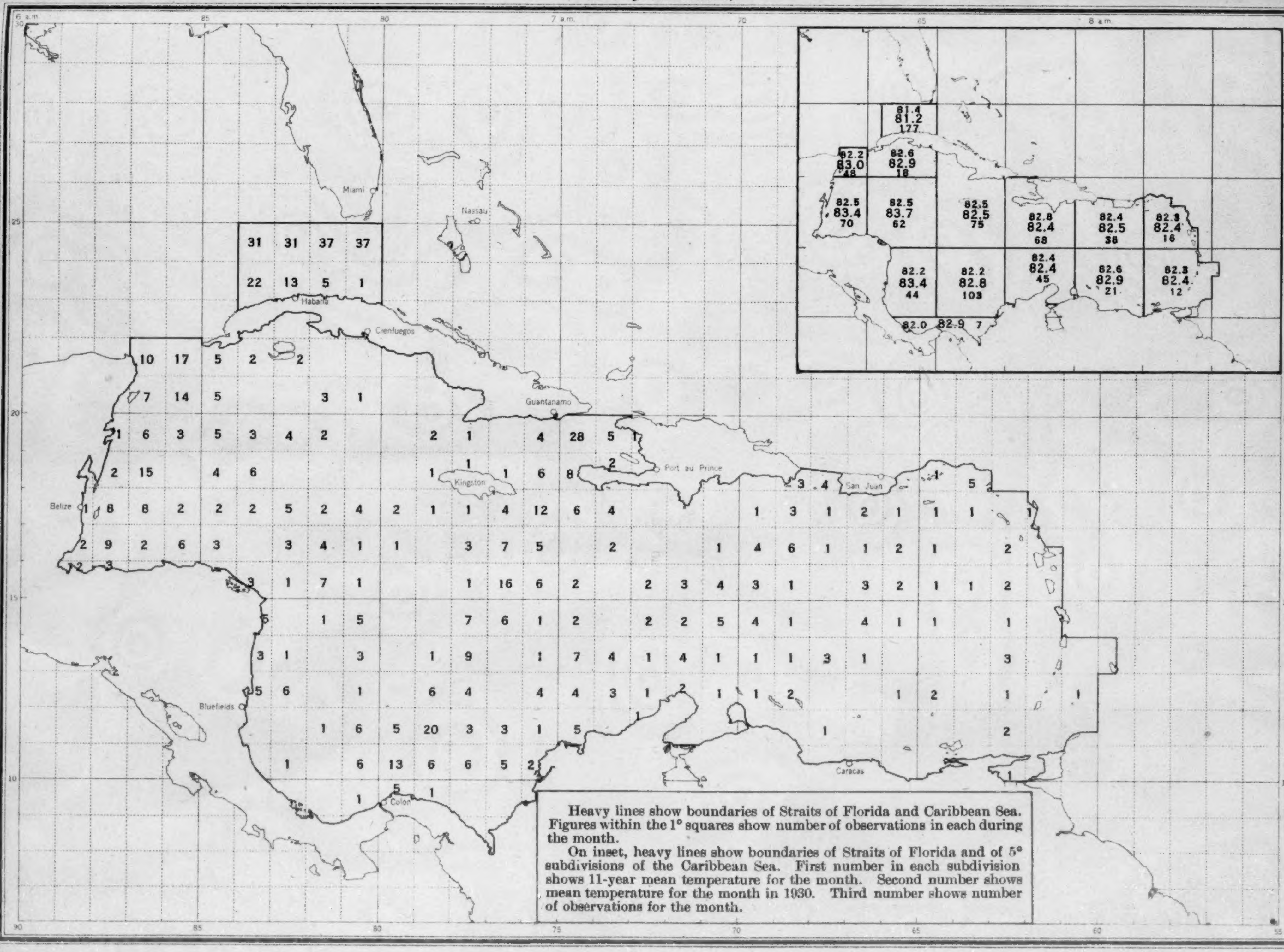
TABLE 2.—*Mean sea-surface temperatures (°F.), and number of observations, October, 1930*

Quarter	Period	Caribbean Sea				Straits of Florida			
		Number of observations	Mean	Departure from 11-year mean (1920–1930)	Change from preceding month	Number of observations	Mean	Departure from 11-year mean (1920–1930)	Change from preceding month
			°F.	°F.	°F.		°F.	°F.	°F.
I	Oct. 1–7	152	82.8			41	82.2		
II	Oct. 8–15	172	82.8			43	81.5		
III	Oct. 16–23	148	83.1			49	81.3		
IV	Oct. 24–31	155	82.8			44	79.6		
Month		627	82.9	+0.4	−0.1	177	81.2	−0.2	−2.3

Distribution of Greenwich Mean Noon Bucket Observations of Sea-Surface Temperatures, October, 1930
(Plotted by Giles Slocum)

Distribution of Greenwich Mean Noon Bucket Observations of Sea-Surface Temperatures, October, 1930

(Plotted by Giles Slocum)



Heavy lines show boundaries of Straits of Florida and Caribbean Sea. Figures within the 1° squares show number of observations in each during the month.

On inset, heavy lines show boundaries of Straits of Florida and of 5° subdivisions of the Caribbean Sea. First number in each subdivision shows 11-year mean temperature for the month. Second number shows mean temperature for the month in 1930. Third number shows number of observations for the month.

CLIMATOLOGICAL TABLES

CONDENSED CLIMATOLOGICAL SUMMARY

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation by sections, October, 1931

[For description of tables and charts, see REVIEW, January, p. 50]

Section	Temperature								Precipitation					
	Section average	Departure from the normal	Monthly extremes						Section average	Departure from the normal	Greatest monthly		Least monthly	
			Station	Highest	Date	Station	Lowest	Date			Station	Amount	Station	Amount
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	68.3	+3.8	Decatur	97	5	Valley Head	30	31	1.73	−0.94	Robertsdale	7.59	Milltown	T.
Arizona	63.5	+0.8	Gila Bend	104	6	Fort Valley	13	31	0.64	−0.17	Henrys Camp	2.50	6 stations	0.00
Arkansas	67.1	+4.7	Dumas	98	10	2 stations	26	31	2.35	−0.82	Gravette	10.22	Wynne	0.65
California	59.4	−0.4	2 stations	102	[1] 5	Twin Lakes	5	26	1.26	+0.04	Camptonville	7.73	26 stations	0.00
Colorado	49.6	+3.0	Las Animas	98	21	Dillon	−7	30	1.00	−0.36	Pagosa Springs	2.98	2 stations	0.00
Florida	74.5	+1.5	Tarpon Springs	95	6	Vernon	35	31	2.41	−1.86	Fort Lauderdale	12.38	Fernandina	0.10
Georgia	67.6	+2.7	2 stations	95	[1] 6	Blairsville	24	20	1.04	−1.69	Moultrie	3.70	Glennville	T.
Idaho	47.8	+0.9	3 stations	89	1	Mud Lake	12	27	1.43	−0.04	Falls Ranger Station	3.68	Challis	0.00
Illinois	59.6	+4.3	2 stations	91	5	Mount Carroll	28	18	3.71	+0.96	Casey	8.37	New Burnside	1.47
Indiana	58.6	+4.0	Scottsburg	90	3	Delphi	25	18	3.72	+0.98	Greencastle	6.72	Vevay (near)	1.80
Iowa	56.8	+5.0	2 stations	92	10	2 stations	28	[1] 17	3.01	+0.58	Bedford	6.67	Allison	0.62
Kansas	61.7	+4.8	Ashland	99	6	2 stations	10	31	1.60	−0.52	Hanover	3.70	Jetmore	0.26
Kentucky	62.0	+3.8	Lovelaceville	93	5	Farmers	28	19	3.01	+0.24	Bardstown	5.77	Pikeville	1.32
Louisiana	72.4	+4.3	3 stations	98	[1] 9	St. Joseph	29	31	3.31	−0.01	Burrwood	13.44	Grand Coteau	0.88
Maryland-Delaware	59.3	+2.9	Stevensville, Md	91	8	Oakland, Md	22	[1] 19	1.78	−1.10	Easton, Md	4.08	Cumberland, Md	0.71
Michigan	53.4	+4.4	Morenci	92	6	2 stations	19	12	3.07	+0.36	Wellston	6.38	Caro	0.72
Minnesota	51.3	+5.6	Beardsley	90	2	Meadowlands	18	12	2.48	+0.63	Pigeon River Bridge	5.72	Milan	0.75
Mississippi	60.5	+4.2	Columbia	98	5	2 stations	31	19	1.82	−0.75	Bay St. Louis	4.82	Vicksburg	0.88
Missouri	61.7	+4.3	2 stations	95	5	Dean	27	31	3.45	+0.56	Dean	6.82	Arcadia	0.99
Montana	46.1	+1.6	do	88	[1] 2	Ingomar (near)	7	30	0.42	−0.63	Crow Agency	2.29	5 stations	0.00
Nebraska	55.6	+4.5	do	93	[1] 4	Gordon	1	31	1.19	−0.41	Falls City	4.60	2 stations	0.23
Nevada	54.3	+2.8	Logandale	96	[1] 4	Zorra Vista Ranch	14	12	0.39	−0.23	Sharp	1.49	Lovelock	0.00
New England	52.6	+3.1	3 stations	86	[1] 18	Hoosac Tunnel, Mass.	18	19	3.29	−0.24	Danforth, Me	7.94	Westfield, Mass	1.44
New Jersey	58.3	+3.4	Canoe Brook	92	8	Layton	24	13	2.76	−0.99	Bayonne	4.69	Culvers Lake	1.67
New Mexico	55.8	+2.3	Carlsbad	95	[1] 6	Elizabethtown	8	30	0.97	−0.25	Carrizozo	4.02	6 stations	0.00
New York	53.2	+3.3	4 stations	86	[1] 3	3 stations	22	[1] 10	2.44	−0.89	High Market	5.48	Dansville	0.73
North Carolina	61.9	+2.0	Southern Pines	96	7	Mount Mitchell	19	31	1.11	−2.23	Brevard	4.26	Willard	0.26
North Dakota	47.7	+4.2	Wahpeton	90	2	Washburn	10	29	1.39	+0.35	Sharon	3.94	Howard	T.
Ohio	57.3	+3.4	5 stations	89	[1] 4	3 stations	25	[1] 18	2.42	−0.29	Franklin	4.80	Cadiz	1.08
Oklahoma	67.3	+5.6	Hollis	103	6	2 stations	19	31	4.43	+1.24	Tahlequah	11.07	Buffalo	0.54
Oregon	49.1	+0.4	Pendleton	93	1	Seneca	−1	12	2.49	+0.48	Crossett	10.08	Kingman	0.06
Pennsylvania	55.7	+3.3	Holtwood	93	7	Ridgway	20	[1] 13	1.83	−1.43	Hamburg	4.30	Wellsboro	0.20
South Carolina	65.9	+2.3	Garnett	98	11	Santuck	28	19	0.80	−2.17	Caesars Head	3.06	2 stations	T.
South Dakota	52.3	+4.0	2 stations	89	[1] 2	Oelrichs	7	31	1.32	−0.06	Webster	3.08	Pollock	0.11
Tennessee	64.2	+4.8	Carthage	96	6	Erwin	22	18	1.88	−0.96	Spencer	3.30	Embreeville	0.68
Texas	72.8	+5.2	Fort Stockton	105	6	Spearman	21	31	2.26	−0.50	Abilene	10.21	4 stations	0.00
Utah	52.1	+2.9	St. George	91	[1] 9	Soldiers Summit	7	27	0.82	−0.50	Monticello	2.43	2 stations	T.
Virginia	60.3	+2.8	Kenbridge	93	6	Burkes Garden	18	19	1.10	−1.89	Christchurch	4.17	Wallaceton	0.00
Washington	49.1	−0.1	2 stations	90	1	Chewelah	16	21	3.64	+0.64	Wynoochee Oxbow	15.27	Sixprong (near)	0.05
West Virginia	57.0	+2.7	Wardensville	98	7	Marlinton	18	19	1.66	−1.47	Terra Alta	3.03	Union	0.58
Wisconsin	52.9	+4.9	2 stations	85	[1] 3	Solon Springs	17	12	3.03	+0.68	West Bend	5.05	Prairie du Chien	1.26
Wyoming	45.1	+2.0	Pinebluff	84	2	Pinedale	6	27	1.31	+0.03	Bechler River	4.55	Powell	0.18
Alaska (Sept.)	43.9	−0.4	Haines	75	7	Barrow	10	[1] 20	3.46	−0.49	Mt. Roberts (b)	22.09	Barrow	0.12
Hawaii	74.8	+1.0	2 stations	94	[1] 10	Kanalohuluhulu	46	31	6.69	+1.21	Kukaua	20.89	Kalae	0.00
Porto Rico	79.1	+0.5	Mayaguez	97	[1] 14	Guineo	53	17	8.43	+0.22	La Fe	20.39	Santa Rita	1.55

[1] Other dates also.

TABLE 1.—*Climatological data for Weather Bureau stations, October, 1931*

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
New England							54.8	+3.7										76	3.26	0.0										4.8		
Eastport	76	67	85	29.86	29.94	-0.06	50.1	+2.0	73	8	56	34	13	44	27	47	44	82	4.72	+1.2	12	7,212	nw.	40	se.	16	8	5	18	6.7	0.0	0.0
Greenville, Me	1,070	6	----	28.79	29.96	----	47.5	----	79	4	57	27	10	38	33	----	----	----	3.87	----	14	5,162	se.	28	----	26	10	7	14	----	T.	0.0
Portland, Me	103	82	117	29.85	29.98	-.06	53.8	+3.9	79	8	62	33	19	46	26	47	42	72	4.35	+1.2	9	5,662	w.	32	nw.	26	15	7	9	4.3	0.0	0.0
Concord	289	70	79	29.69	30.01	-.04	51.6	+1.9	84	4	63	29	11	40	40	----	----	----	3.45	+0.6	9	3,386	nw.	21	nw.	27	15	4	12	4.8	0.0	0.0
Burlington	403	11	48	29.56	30.00	-.04	51.6	+2.4	79	4	60	29	10	43	32	----	----	----	2.52	-0.4	12	6,472	s.	37	s.	11	9	7	15	6.2	0.0	0.0
Northfield	876	12	60	----	30.02	-.02	48.6	+3.1	80	4	60	23	10	37	41	----	----	82	2.28	-0.6	14	4,339	s.	25	s.	11	9	9	13	5.9	0.0	0.0
Boston	125	106	165	29.86	30.00	-.05	58.5	+4.9	84	5	67	40	19	50	26	51	45	69	2.18	-1.0	7	5,055	nw.	27	nw.	27	15	9	7	4.1	0.0	0.0
Nantucket	12	14	90	29.99	30.00	-.05	57.7	+3.5	76	6	64	42	19	52	19	53	50	80	5.57	+2.2	9	10,023	sw.	36	sw.	17	12	8	11	5.1	0.0	0.0
Block Island	26	11	46	29.98	30.01	-.04	58.0	+3.1	76	6	63	43	18	53	18	53	50	78	4.41	+0.8	8	10,342	w.	46	nw.	26	18	8	5	3.9	0.0	0.0
Providence	160	215	251	29.83	30.00	-.05	57.4	+5.2	82	8	67	35	19	48	27	51	46	72	2.40	-0.7	9	7,205	nw.	42	nw.	25	17	9	5	3.5	0.0	0.0
Hartford	159	122	----	29.84	30.01	-.05	57.5	+6.3	83	3	68	37	13	48	34	----	----	----	1.75	-1.8	9	----	sw.	----	----	----	14	10	7	4.2	0.0	0.0
New Haven	106	74	153	29.92	30.03	-.03	58.1	+4.3	83	8	68	38	19	49	29	51	47	73	2.23	-1.4	8	4,987	sw.	27	nw.	26	15	11	5	3.8	0.0	0.0
Middle Atlantic States							60.0	+3.4										73	1.61	-1.4										4.5		
Albany	97	107	115	29.92	30.03	-.03	55.0	+2.9	82	5	64	34	10	45	31	48	44	75	1.37	-1.4	10	3,742	s.	20	nw.	26	15	4	12	4.6	0.0	0.0
Binghamton	871	10	84	29.13	30.07	+.01	53.3	+3.3	81	5	65	28	13	42	39	----	----	----	1.02	-2.0	10	3,154	e.	21	nw.	26	10	3	18	6.0	0.0	0.0
New York	314	414	454	29.70	30.04	-.02	60.4	+4.1	85	6	68	41	19	52	25	53	48	70	2.87	-0.7	11	9,474	nw.	50	nw.	26	11	12	8	5.1	0.0	0.0
Bellefonte	1,050	5	36	28.96	30.08	----	53.0	----	82	4	66	25	20	40	45	47	43	79	1.04	----	8	----	w.	36	w.	16	7	10	14	6.0	0.0	0.0
Harrisburg	374	94	104	29.67	30.07	-.01	58.9	+4.1	84	6	69	37	13	49	32	51	45	68	2.13	-0.8	8	3,576	w.	26	nw.	25	13	10	8	4.5	0.0	0.0
Philadelphia	114	123	367	29.95	30.08	+.01	62.6	+4.8	85	6	71	45	19	54	24	54	48	66	2.61	-0.2	8	7,802	sw.	34	n.	12	12	10	9	4.6	0.0	0.0
Reading	325	81	103	29.72	30.07	----	58.8	+4.1	85	4	69	37	13	49	29	52	49	76	2.06	-1.1	7	2,983	sw.	22	w.	25	13	10	8	4.7	0.0	0.0
Scranton	805	72	103	29.22	30.08	+.01	54.9	+3.0	83	4	66	30	13	44	37	48	45	77	1.45	-1.6	10	3,565	n.	33	nw.	25	10	11	10	5.0	0.0	0.0
Atlantic City	52	37	172	30.00	30.06	-.01	61.5	+4.6	80	6	69	40	19	54	26	55	52	75	2.11	-1.1	8	9,542	w.	40	w.	25	16	8	7	3.9	0.0	0.0
Cape May	17	13	49	----	----	----	61.6	+2.0	82	3	69	40	19	54	25	57	53	78	1.94	-1.4	7	----	nw.	----	----	----	12	11	8	----	0.0	0.0
Sandy Hook	22	10	55	30.02	30.04	----	60.6	----	82	6	67	44	19	54	22	54	51	76	2.41	-1.4	11	8,823	w.	38	n.	25	13	11	7	4.2	0.0	0.0
Trenton	190	159	183	29.86	30.06	----	59.6	+4.0	86	6	70	37	19	49	28	52	47	72	2.22	-0.6	10	5,770	w.	31	nw.	26	13	10	8	4.4	0.0	0.0
Baltimore	123	100	215	29.94	30.07	-.01	63.4	+5.2	88	8	73	44	18	54	30	54	48	64	1.79	-1.1	4	5,605	sw.	32	sw.	25	13	10	8	4.3	0.0	0.0
Washington	112	62	85	29.96	30.08	.00	61.2	+3.8	88	6	72	37	19	50	38	53	48	72	1.28	-1.6	7	3,017	sw.	24	nw.	17	16	10	5	4.1	0.0	0.0
Cape Henry	18	8	54	30.07	30.09	----	64.8	+2.7	88	7	73	45	20	57	25	58	54	74	0.57	-2.4	4	7,436	sw.	45	n.	26	14	14	3	3.8	0.0	0.0
Lynchburg	681	153	188	29.37	30.12	+.03	61.0	+2.5	87	7	74	34	19	48	44	52	47	71	0.67	-2.5	6	2,992	nw.	20	w.	25	18	7	6	4.0	0.0	0.0
Norfolk	91	170	205	30.01	30.11	+.04	65.2	+2.7	88	6	74	47	20	57	24	57	52	70	0.74	-2.3	3	7,097	s.	29	nw.	17	17	10	4	3.7	0.0	0.0
Richmond	144	11	52	29.96	30.11	+.03	62.3	+2.7	88	7	75	36	19	50	36	55	52	80	1.15	-1.7	7	3,980	sw.	26	sw.	28	15	11	5	3.5	0.0	0.0
Wytheville	2,304	49	55	27.76	30.14	+.05	55.6	+2.0	81	5	68	26	19	43	43	48	43	73	0.62	-2.2	4	3,502	w.	22	sw.	25	14	7	10	4.3	0.0	0.0
South Atlantic States							67.1	+2.8										71	0.78	-2.5										3.4		
Asheville	2,253	89	104	27.81	30.16	+.07	58.8	+3.5	84	5	72	30	19	45	44	49	44	71	0.49	-2.3	5	3,729	nw.	22	nw.	25	18	8	5	4.0	0.0	0.0
Charlotte	779	55	62	29.30	30.13	+.05	65.0	+3.3	90	6	77	39	19	54	34	54	48	64	1.26	-1.7	4	2,292	sw.	16	w.	15	18	8	5	3.2	0.0	0.0
Greensboro	886	5	56	29.18	30.14	----	60.4	----	89	6	75	28	18	46	46	51	48	76	0.45	----	5	4,039	sw.	25	nw.	15	18	7	6	3.5	0.0	0.0
Hatteras	11	5	50	30.08	30.10	+.04	67.2	+1.3	84	5	74	50	21	60	23	64	63	89	0.64	-4.3	4	6,905	ne.	30	ne.	12	18	9	4	3.1	0.0	0.0
Raleigh	376	103	146	29.72	30.12	+.05	64.6	+2.6	88	6	76	41	19	54	32	55	49	64	0.80	-2.1	3	4,805	sw.	25	nw.	15	19	7	5	3.2	0.0	0.0
Wilmington	78	81	91	30.05	30.13	+.07	67.0	+1.7	85	5	78	44	19	56	33	59	55	75	0.50	-2.8	2	3,494	n.	24	sw.	29	21	7	3	2.7	0.0	0.0
Charleston	48	11	92	30.06	30.11	+.05	70.2	+2.4	85	25	78	48	31	62	26	63	60	76	0.71	-2.6	4	6,397	ne.	27	ne.	18	18	8	5	3.4	0.0	0.0
Columbia, S. C	351	41	57	29.75	30.13	+.06	67.5	+3.2	89	6	80	42	19	55	38	56	49	60	0.53	-2.0	2	3,714	ne.	26	sw.	28	22	7	2	2.4	0.0	0.0
Due West	711	10	55	29.39	30.17	----	65.2	----	88	6	78	38	31	53	38	----	----	----	1.45	----	3	4,626	w.	30	ne.	9	17	9	5	3.6	0.0	0.0
Greenville, S. C	1,039	139	146	29.03	30.13	----	65.8	+5.6	87	6	76	39	31	56	30	54	46	58	1.06	-2.1	6	4,404	ne.	28	w.	25	18	10	3	3.0	0.0	0.0
Augusta	182	62	77	29.91	30.10	+.03	68.3	+3.0	90	12	82	40	20	55	42	58	53	70	0.40	-2.1	2	2,721	nw.	19	sw.	28	21	5	5	2.8	0.0	0.0
Savannah	65	150	194	30.03	30.10	+.05	70.6	+2.7	87	25	80	46	31	61	20	62	59	77	0.34	-2.6	4	6,840	e.	26	w.	29	16	8	7	4.1	0.0	0.0
Jacksonville	43	209	245	30.03	30.08	+.06	72.9	+1.8	84	9	80	48	31	66	24	65	62	75	1.86	-2.6	6	7,578	ne.	27	n.	13	8	16	7	5.2	0.0	0.0
Florida Peninsula							77.7	+0.9										79	4.74	-1.1										5.7		
Key West	22	10	64	29.95	29.97	+.03	79.1	0.0	87	6	84	66	31	74	15	74	72	82	8.02	+2.0	17	6,752	ne.	27	s.	17	12	9	10	4.9	0.0	0.0
Miami	25	124	168	29.98	30.00	+.03	78.2	+1.2	88	16	83	61	31	74	17	72	69	76	5.66	-2.8	14	7,415	ne.	38	ne.	19	6	11	14	6.5	0.0	0.0
Tampa	35	79	197	30.00	30.04	+.06	75.8	+1.5	90	7	84	56	31	68	21	68	65	78	0.54	-2.6	7	7,650	e.	33	e.	19	9	14	8	5.2	0.0	0.0
Titusville	44	5	----	30.00	30.05	----	75.9	----	90	3	83	54	31	69	24	----	----	----	2.98	----	14	----	ne.	----	----	----	5	17	9	6.1	0.0	0.0
East Gulf States							69.9	+3.5										71	1.99	-0.9										3.6		
Atlanta	1,173	190	198	28.90	30.13	+.06	66.0	+3.0	86	12	75	40	31	57	26	55	47	59	1.05	-1.5	3	5,444	e.	25	w.	29	17	9	5	3.3	0.0	0.0
Macon	370	78	87	29.73	30.12	+.06	66.5	+2.0	88	6	79	41	20	54	38	56	51	67	1.42	-0.9	3	3,379	ne.	19	sw.	28	19	5	7	3.2	0.0	0.0
Thomasville	273	49	103	29.79	30.09	+.05	71.3	+3.1	89	6	82	43	31	61	30	62	57	71	0.80	-2.1	2	4,435	ne.	17	ne.	2	15	10	6	4.2	0.0	0.0
Apalachicola	36	11	51	30.03	30.07	----	73.0	----	90	15	80	48	31	66	23	66	64	77	0.15	-3.0	2	5,734	e.	24	e.	1	16	8	7	3.7	0.0	0.0
Pensacola	56	149	185	30.02	30.08	+.05	72.4	+2.5	88	10	78	44	31	66	18	65	62	74	5.83	+1.6	4	8,050	e.	47	sw.	7	16	11	4	3.4	0.0	0.0
Anniston	741	9	57	----	----	----	65.6	+3.2	89	6	79	37	30	52	43	----	----	----	0.46	-2.2	2	2,599	se.	18	w.	29	16	9	6	----	0.0	0.0
Birmingham	700	11	48	29.36	30.12	+.05	69.4	+4.6	92	5	80	41	30	58	28	58	52	65	2.05	-0.4	3	3,683	se.	17	sw.	28	16	13	2	3.0	0.0	0.0
Mobile	57	125	161	30.02	30.08	+.04	72.6	+3.3	89	10	81	45	31	64	26	65	62	77	3.58	0.0	7	5,290	e.	22	se.	4	16	11	4	3.7	0.0	0.0
Montgomery	223	100	112	29.87	30.12	+.06	70.0	+3.4	89	12	80	44	31	60	34	59	53	65	0.88	-1.6	3	3,652	e.	20	e.	1	18	8	5	3.2	0.0	0.0
Corinth	469	6	----	----	----	----	68.2	----	93	6	82	36	19	54	44	----	----	----	1.28	----	2	----	se.	----	----	----	11	19	1	----	0.0	0.0
Meridian	375	87	95	29.70	30.09	+.03	68.8	+4.5	89	10	80	40	31	58	35	60	57	75	1.37	-1.0	4	2,491	se.	17	w.	29	16	8	7	4.0	0.0	0.0
Vicksburg	247	65	73	29.82	30.10	+.04	71.4	+4.7	92	10	81	40	31	62	30	62	57	71	0.88	-1.9	7	4,000	se.	20	w.	29	15	10	6	3.6	0.0	0.0
New Orleans	53	76	84	30.01	30.06	+.03	75.2	+4.2	88	11	81	52	31	69	19	67	64	78	5.36	+2.1	9	3,914	e.	17	e.	1	17	6	8	4.2	0.0	0.0
West Gulf States							73.8	+5.9										72	2.47	-0.6										3.7		
Shreveport	249	204	220	29.80	30.06	+.01	72.3	+5.7	94	9	82	41	31	62	30	62	57	67	2.66	0.0	4	5,638	s.	29	n.	28	22	7	2	2.8	0.0	0.0
Bentonville	1,303	11	44	28.69	30.04	-.01	64.3	+6.3	90	4	75	32	31	54	32	----	----	----	8.36	----	9	2,388	s.	16	nw.	29	21	5	5	----	0.0	0.0
Fort Smith	457	79	94	29.57	30.04	-.01	68.4	+5.6	93	10	79	36	31	58	28	60	55	70	6.32	+3.3	8	4,488	e.	34	nw.	29	15	12	4	4.1	0.0	0.0
Little Rock	357	136	153	29.70	30.08	+.02	68.2	+4.6	91	10	78	40	31	58	30	59	54	70	1.76	-1.0	6	4,489	s.	31	w.	29	12	12	7	4.6	0.0	0.0
Austin	605	136	148	29.39	30.02	----	77.0	+8.7	95	7	88	43	31	66	30	65	60	66	0.15	-3.0	3	4,495	se.	25	ne.	15	13	16	2	3.9	0.0	0.0
Brownsville	57	83	100	29.93	29.99	----	79.2	+4.3	94	6	88	60	31	71	22	71	69	80	4.47	+1.2	9	5,482	se.	21	e.	9	15	12	4	4.0	0.0	0.0
Corpus Christi	20	11	78	29.99	30.01	+.01	79.0	+5.8	90	28	84	63	30	74	19	72	69	77	0.34	-2.1	5	7,083	se.	27	ne.	1	17	12	2	3.9	0.0	0.0
Dallas	512	220	227	29.49	30.04	----	71.7	----	92	9	81	42	31	62	27	----	----	----	2.26	-0.4	8	7,150	se.	31	ne.	15	19	6	6	3.3	0.0	0.0
Fort Worth	670	106	114	29.31	30.02	-.01	72.7	+6.0	95	7	82	42	31	63	28	62	57	68	3.39	+0.6	8	4,990	se.	22	nw.	29	18	6	7	4.0	0.0	0.0
Galveston	54	106	114	30.00	30.06	+.03	76.6	+3.9	85	5	81	57	31	72	21	70	66	75	3.40	-1.0	7	6,926	se.	25	se.	23	17	11	3	3.3	0.0	0.0
Houston	138	292	314	29.90	30.04	----	75.6	+5.3	93	7	84	50	31	67	24	----	----	----	1.09	-2.6	4	7,791	se.	29	se.	15	13	17	1	3.8	0.0	0.0
Palestine	510	64	72	29.53	30.06	+.03	73.0	+5.8	93	9	83	44	31	63	30	63	58	69	2.81	-0.5	4	4,270	s.	18	nw.	23	16	12	3	3.3	0.0	0.0
Port Arthur	34	58	66	30.00	30.04	----	75.6	----	90	8	83	47	31	68	24	68	66	80	5.14	+1.8	7	4,391	e.	21	n.	15	13	16	2	3.8	0.0	0.0
San Antonio	693	242	301	29.29	29.99	-.02	78.0	+7.5	96	7	88	51	31	68	25	67	62	66	0.75	-1.5	5	7,185	e.	32	se.	11	12	18	1	3.8	0.0	0.0
Taylor	571	38	51	29.47	30.06	+.04	75.6	+7.3	95	7	87	41	31	64	31	----	----	----	0.28	-2.8	2	4,719	s.	21	n.	15	17	13	1	3.1	0.0	0.0

TABLE 1.—*Climatological data for Weather Bureau stations, October, 1931*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
Ohio Valley and Tennessee							61.0	+3.3										72	2.59	−0.1										5.0		
Chattanooga	762	190	215	29.30	30.12	+0.03	65.4	+3.5	87	6	76	42	19	55	35	54	47	60	1.73	−1.3	3	3,671	se.	20	sw.	29	16	12	3	3.5	0.0	0.0
Knoxville	995	102	111	29.08	30.14	+.05	63.2	+3.3	89	6	75	37	18	52	39	53	48	67	1.42	−1.2	2	2,991	ne.	18	sw.	29	15	10	6	4.0	0.0	0.0
Memphis	399	76	97	29.67	30.09	+.02	69.0	+5.7	90	11	79	38	31	59	30	59	53	66	0.79	−1.9	4	4,412	se.	23	sw.	27	14	12	5	4.1	0.0	0.0
Nashville	546	168	191	29.54	30.13	+.05	65.2	+4.2	89	5	77	39	19	54	37	56	50	66	1.86	−0.6	7	4,928	s.	28	nw.	27	15	9	7	4.2	T.	T.
Lexington	989	193	230	29.07	30.14	+.06	60.8	+3.4	84	3	69	37	18	52	27	—	—	—	4.44	+1.8	12	8,137	sw.	29	sw.	27	17	3	11	4.0	0.0	0.0
Louisville	525	188	234	29.53	30.12	+.04	61.6	+2.3	86	3	71	39	19	52	31	53	48	70	2.36	−0.3	10	5,928	s.	32	sw.	27	11	9	11	5.2	0.0	0.0
Evansville	431	76	116	29.63	30.10	+.02	63.4	+4.0	85	4	73	40	18	54	31	55	50	71	1.83	−1.0	9	5,202	s.	40	sw.	27	13	7	11	4.9	0.0	0.0
Indianapolis	822	194	230	29.20	30.09	+.02	59.4	+3.7	84	5	68	39	18	51	26	52	46	69	3.75	+1.0	12	6,770	s.	38	nw.	7	8	11	12	5.9	0.0	0.0
Royal Center	736	11	55	29.26	30.07	—	57.2	—	85	5	67	31	18	47	29	—	—	—	3.05	+0.1	13	5,754	sw.	25	s.	27	8	8	15	5.8	0.0	0.0
Terre Haute	575	96	129	29.46	30.08	—	60.2	—	84	3	69	38	18	51	30	52	48	72	6.48	+3.8	12	5,651	s.	28	sw.	7	10	8	13	5.5	0.0	0.0
Cincinnati	627	11	51	29.43	30.11	+.03	59.4	+3.7	84	4	70	34	19	49	36	52	48	75	1.89	−0.6	9	3,868	sw.	19	sw.	27	12	10	9	5.0	0.0	0.0
Columbus	822	216	230	29.22	30.10	+.02	58.2	+3.0	82	4	68	35	18	49	29	51	47	73	2.41	0.0	13	6,272	s.	31	w.	16	12	9	10	5.1	0.0	0.0
Dayton	899	137	173	29.14	30.10	—	58.8	+3.8	82	5	68	36	18	50	30	52	47	74	4.06	+2.1	10	4,933	sw.	28	sw.	27	11	10	10	5.4	0.0	0.0
Elkins	1,947	59	67	28.10	30.17	+.07	53.8	+1.5	82	7	66	26	19	42	41	47	45	86	1.50	−1.4	13	2,684	w.	29	nw.	16	6	14	11	6.3	0.0	0.0
Parkersburg	637	77	82	29.48	30.14	+.06	58.4	+2.3	86	7	69	31	19	48	36	51	48	79	2.04	−0.4	9	2,917	se.	29	nw.	16	10	7	14	5.9	0.0	0.0
Pittsburgh	842	353	410	29.20	30.11	+.03	57.4	+1.7	84	7	66	37	18	48	29	50	46	74	1.21	−1.3	11	5,443	sw.	35	w.	25	9	8	14	5.7	0.0	0.0
Lower Lake Region							56.2	+4.2										72	2.18	−0.7										5.5		
Buffalo	767	247	280	29.20	30.03	−.02	55.6	+3.7	77	4	62	36	17	49	29	50	45	73	1.97	−1.3	14	10,471	w.	44	sw.	11	12	9	10	5.4	0.0	0.0
Canton	448	10	61	29.51	29.99	—	51.4	+4.2	79	4	61	28	9	42	35	—	—	—	2.55	−0.5	11	5,241	sw.	30	sw.	11	11	6	14	5.6	T.	0.0
Ithaca	836	74	100	29.14	30.05	—	54.5	+3.4	83	3	65	29	13	44	39	47	42	70	0.99	−2.0	9	5,468	nw.	27	nw.	11	10	6	15	5.7	0.0	0.0
Oswego	335	71	85	—	30.02	−.03	55.0	+3.8	81	4	63	33	10	47	30	—	—	74	2.95	−0.3	13	6,053	s.	27	nw.	11	11	5	15	5.9	0.0	0.0
Rochester	523	86	102	29.47	30.05	.00	56.0	+4.5	82	4	65	35	13	47	34	48	43	70	1.59	−1.1	11	5,244	sw.	23	sw.	5	10	9	12	5.6	0.0	0.0
Syracuse	596	65	79	29.40	30.04	−.02	56.5	+5.5	84	4	65	35	18	48	30	—	—	—	1.76	−1.1	14	4,032	s.	23	nw.	25	13	5	13	5.5	0.0	0.0
Erie	714	130	166	29.29	30.06	+.01	57.0	+3.6	84	4	65	38	17	50	28	50	46	74	3.53	−0.2	12	8,848	s.	30	s.	29	13	8	10	5.0	T.	0.0
Cleveland	762	267	337	29.24	30.06	.00	58.5	+4.9	81	4	65	41	30	52	24	51	45	65	1.76	−1.0	13	9,949	s.	50	w.	16	9	10	12	5.8	0.0	0.0
Sandusky	629	5	67	29.39	30.08	+.02	57.7	+3.4	85	4	66	35	18	49	29	—	—	—	2.37	−0.1	11	5,416	sw.	27	nw.	16	8	9	14	5.8	0.0	0.0
Toledo	628	208	243	29.39	30.07	+.02	57.4	+4.0	83	5	66	36	18	49	28	50	46	73	1.79	−0.6	12	8,370	sw.	36	nw.	16	15	4	12	5.0	0.0	0.0
Fort Wayne	856	110	119	29.14	30.07	—	57.5	+3.8	84	5	66	34	18	49	27	51	47	75	2.42	−0.2	12	5,851	sw.	28	nw.	16	13	4	14	5.5	0.0	0.0
Detroit	730	218	258	29.27	30.07	+.02	57.5	+5.0	82	5	66	36	18	49	27	50	46	73	2.43	0.0	13	6,500	sw.	27	sw.	7	9	13	9	5.4	0.0	0.0
Upper Lake Region							54.0	+5.4										78	2.95	+0.2										5.8		
Alpena	609	13	92	29.34	30.00	−.03	52.6	+5.5	82	3	62	31	18	44	29	48	44	79	2.96	+0.2	12	7,366	nw.	36	nw.	11	13	7	11	5.2	0.0	0.0
Escanaba	612	54	60	29.31	29.98	−.03	52.2	+6.2	73	14	59	33	12	46	29	48	45	79	3.09	+0.5	13	6,949	s.	37	nw.	11	10	7	14	6.0	0.0	0.0
Grand Haven	632	54	80	29.34	30.02	−.01	54.3	+3.6	76	3	62	33	18	47	21	50	47	81	2.86	−0.2	14	7,619	sw.	30	nw.	16	11	4	16	6.1	0.0	0.0
Grand Rapids	707	70	244	29.26	30.04	.00	55.8	+4.6	82	3	64	35	18	48	30	49	46	76	3.18	+0.4	13	7,858	sw.	40	sw.	28	9	7	15	6.0	0.0	0.0
Houghton	668	64	99	29.21	29.94	−.06	53.2	+7.5	82	2	61	35	12	46	32	—	—	—	3.02	0.0	16	6,156	w.	34	nw.	11	8	8	15	6.1	0.0	0.0
Lansing	878	6	88	29.09	30.04	—	53.4	+3.1	81	4	63	30	18	44	32	49	47	86	1.80	−0.7	13	5,297	sw.	27	nw.	16	8	11	12	5.8	T.	0.0
Ludington	637	60	66	29.31	30.00	—	53.6	+3.9	73	3	60	35	12	48	30	50	47	81	5.64	+2.7	18	7,302	s.	33	sw.	28	13	9	9	4.9	0.0	0.0
Marquette	734	77	111	29.15	29.95	−.06	53.9	+7.2	82	2	61	36	17	47	30	47	43	74	3.15	+0.4	13	8,124	s.	36	w.	24	7	6	18	6.8	T.	0.0
Port Huron	638	70	120	29.34	30.03	−.01	55.4	+4.9	80	4	64	33	18	47	29	49	46	77	1.35	−1.1	10	6,989	s.	29	nw.	17	11	9	11	5.5	0.0	0.0
Sault Sainte Marie	614	11	52	29.29	29.99	−.02	50.9	+6.3	76	3	58	31	18	43	29	46	44	83	2.82	−0.9	15	5,601	se.	33	nw.	25	9	6	16	6.5	0.0	0.0
Chicago	673	7	131	29.32	30.04	.00	58.8	+4.8	83	3	66	40	18	52	24	52	48	74	2.62	+0.1	11	6,965	sw.	29	ne.	11	12	8	11	5.4	0.0	0.0
Green Bay	617	109	141	29.32	29.98	−.04	53.8	+5.3	79	3	61	36	18	46	25	48	44	77	3.76	+1.2	10	7,032	s.	27	sw.	27	8	7	16	6.2	0.0	0.0
Milwaukee	681	125	221	29.28	30.01	−.02	56.7	+5.6	82	3	64	39	29	50	25	50	46	73	2.10	−0.2	10	9,018	w.	33	w.	7	10	9	12	5.5	0.0	0.0
Duluth	1,133	5	47	28.71	29.93	−.07	50.9	+6.8	79	2	60	33	12	42	27	45	41	77	2.90	+0.6	14	8,235	sw.	38	nw.	10	11	7	13	5.7	0.0	0.0
North Dakota							48.4	+4.6										72	1.53	+0.3										5.0		
Moorhead	940	50	58	28.92	29.95	−.05	50.5	+6.0	86	2	61	31	12	40	42	44	39	74	2.34	+0.6	8	6,173	s.	30	nw.	27	11	6	14	5.7	T.	0.0
Bismarck	1,674	8	57	28.18	29.98	−.01	48.6	+3.7	82	1	60	29	11	38	38	41	37	73	1.19	+0.2	8	6,330	nw.	38	nw.	27	16	6	9	4.3	0.2	0.0
Devils Lake	1,478	11	44	28.37	29.96	−.03	47.0	+4.6	82	2	57	29	12	37	34	41	37	78	2.29	+1.0	5	6,821	sw.	30	nw.	27	9	8	14	5.8	0.1	0.0
Ellendale	1,457	10	56	28.38	29.96	—	48.8	—	84	2	61	28	11	37	46	—	—	—	1.66	+0.5	9	9,635	nw.	43	nw.	27	12	5	14	5.5	1.0	0.0
Grand Forks	833	12	67	—	—	—	48.7	—	84	1	60	27	11	38	44	42	—	—	3.65	—	9	—	nw.	39	nw.	10	9	8	14	—	0.0	0.0
Williston	1,878	41	48	28.00	29.99	+.01	47.6	+4.2	78	1	60	23	22	36	41	39	33	65	0.15	−0.7	2	5,377	w.	32	nw.	27	16	9	6	3.8	0.0	0.0
Upper Mississippi Valley							58.4	+5.3										75	2.93	+0.5										5.5		
Minneapolis	918	102	208	28.96	29.94	—	54.4	+5.5	81	2	63	38	30	46	30	—	—	—	1.87	−0.2	13	7,718	se.	34	se.	26	13	4	14	5.5	0.0	0.0
St. Paul	837	114	149	29.05	29.96	−.05	54.2	+5.6	80	2	63	37	25	46	30	—	—	—	2.31	+0.1	13	5,492	sw.	28	w.	27	13	5	13	5.3	0.0	0.0
La Crosse	714	11	48	29.21	29.99	−.03	55.2	+4.9	81	3	64	33	17	47	33	50	47	83	4.18	+1.9	12	3,240	s.	18	sw.	27	14	1	16	5.7	0.0	0.0
Madison	974	70	78	28.96	30.00	−.03	54.9	+4.6	80	3	62	38	29	48	27	49	45	76	3.11	+0.7	12	5,761	s.	24	sw.	27	12	5	14	5.4	T.	0.0
Wausau	1,247	4	62	28.64	29.98	—	51.9	—	78	3	60	31	18	43	35	—	—	—	2.51	−0.3	12	4,269	s.	24	sw.	27	10	4	17	6.4	0.0	0.0
Charles City	1,015	10	51	28.93	30.02	—	55.0	+6.4	81	2	64	33	17	46	30	49	45	79	1.07	−1.3	8	4,625	se.	23	w.	27	15	5	11	5.1	0.0	0.0
Davenport	606	143	118	29.37	30.03	−.01	59.0	+5.3	82	3	67	39	31	51	23	52	48	73	3.01	+0.6	15	6,553	s.	34	w.	27	10	7	14	5.8	0.0	0.0
Des Moines	861	5	99	29.10	30.01	−.02	58.6	+5.2	84	10	67	37	29	50	26	52	48	76	3.54	+1.0	13	6,798	s.	32	nw.	7	11	7	13	5.6	0.0	0.0
Dubuque	700	81	96	29.26	30.02	−.02	56.8	+4.9	81	3	64	35	18	50	26	51	47	76	2.92	+0.4	11	3,899	s.	19	n.	16	12	3	16	6.0	0.0	0.0
Keokuk	614	64	78	29.38	30.05	−.02	60.4	+5.0	87	5	69	40	31	52	28	53	49	73	4.05	+1.8	12	4,807	sw.	29	w.	5	12	8	11	5.1	0.0	0.0
Cairo	358	87	93	29.70	30.08	+.01	65.0	+4.6	86	7	74	42	31	56	29	56	52	72	2.66	−0.1	8	4,636	s.	25	sw.	27	10	10	11	5.2	0.0	0.0
Peoria	609	11	45	29.40	30.06	+.01	59.2	+7.2	88	5	68	34	18	50	30	52	49	78	3.15	+0.9	13	3,633	s.	21	w.	28	12	7	12	5.2	0.0	0.0
Springfield, Ill.	636	5	191	29.37	30.06	.00	60.7	+4.9	88	5	70	38	18	52	28	53	49	73	3.51	+1.0	10	8,124	s.	29	se.	7	11	5	15	5.8	0.0	0.0
Hannibal	534	74	109	29.48	30.06	.00	61.4	+5.4	88	5	70	37	18	53	27	—	—	—	3.16	+0.8	10	5,737	sw.	23	w.	28	12	5	14	5.5	0.0	0.0
St. Louis	568	265	303	29.46	30.06	.00	62.9	+6.1	87	4	71	42	29	55	26	54	49	68	2.90	+0.2	10	8,299	s.	31	sw.	23	13	6	12	4.8	0.0	0.0
Missouri Valley							58.3	+4.6										69	1.87	−0.2										4.9		
Columbia, Mo.	784	6	84	29.22	30.05	.00	62.0	+5.4	87	6	71	40	18	53	29	—	—	—	3.15	+0.5	10	4,708	s.	20	w.	29	12	9	10	5.1	0.0	0.0
Kansas City	963	161	181	29.02	30.05	+.01	62.5	+4.8	89	10	71	38	30	54	27	54	50	69	3.02	+0.1	9	6,286	s.	34	sw.	27	12	9	10	5.1	T.	0.0
St. Joseph	967	11	49	28.99	30.03	—	60.8	—	90	10	70	37	17	52	28	53	49	74	1.92	−0.8	9	5,553	nw.	37	w.	26	13	10	8	4.6	T.	0.0
Springfield, Mo.	1,324	98	104	28.66	30.06	+.01	62.6	+4.4	85	10	71	36	18	54	33	54	50	70	3.18	−0.5	10	6,718	s.	30	w.	29	14	7	10	4.6	0.0	0.0
Iola	984	11	50	29.00	30.04	.00	63.7	+5.9	91	10	74	33	31	54	30	—	—	—	2.05	−0.9	11	3,788	s.	20	s.	26	13	6	12	5.4	0.0	0.0
Topeka	987	92	107	—	—	—	61.4	+5.4	90	10	70	36	31	53	29	—	—	—	2.55	+0.1	8	6,447	sw.	31	w.	26	13	8	10	4.7	0.0	0.0
Lincoln	1,189	11	81	28.74	30.01	−.02	59.0	+4.8	91	10	69	35	31	49	33	51	47	70	1.56	−0.3	6	7,169	s.	33	nw.	29	13	7	11	5.0	0.0	0.0
Omaha	1,105	115	122	28.83	30.01	−.02	59.2	+4.9	89	10	68	36	30	50	30	51	46	69	2.61	+0.4	7	5,187	s.	27	nw.	27	12	12	7	4.5	0.0	0.0
Valentine	2,598	47	54	27.31	30.03	+.02	52.6	+3.3	84	19	65	23	31	40	42	44	37	64	0.55	−0.6	6	6,326	n.	37	nw.	26	13	8	10	5.0	0.1	0.0
Sioux City	1,135	94	164	28.78	29.99	−.03	55.8	+4.4	85	10	65	34	17	47	40	49	44	71	1.16	−0.6	6	8,813	nw.	42	s.	26	12	8	11	5.2	T.	0.0
Huron	1,306	59	74	28.59	30.00	−.01	52.5	+4.8	84	2	63	31	31	42	37	45	39	70	1.19	−0.1	9	6,980	s.	40	nw.	27	14	5	12	5.1	T.	0.0
Pierre	1,572	70	75	28.31	29.98	−.01	53.6	+3.8	88	5	66	23	31	42	39	45	37	63	0.41	−0.4	5	6,164	nw.	39	nw.	27	15	7	9	4.6	T.	0.0
Yankton	1,233	49	57	28.68	30.00	−.01	55.2	+4.1	83	2	65	32	31	46	34	—	—	—	1.62	+0.2	8	5,224	nw.	32	w.	27	12	8	11	5.3	T.	0.0

TABLE 1.—*Climatological data for Weather Bureau stations, September, 1931*—Continued

District and station	Elevation of instruments			Pressure			Temperature of the air										Mean wet thermometer	Mean temperature of the dew point	Mean relative humidity	Precipitation			Wind					Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Barometer above sea level	Thermometer above ground	Anemometer above ground	Station, reduced to mean of 24 hours	Sea level, reduced to mean of 24 hours	Departure from normal	Mean max. + mean min. ÷ 2	Departure from normal	Maximum	Date	Mean maximum	Minimum	Date	Mean minimum	Greatest daily range				Total	Departure from normal	Days with 0.01 or more	Total movement	Prevailing direction	Maximum velocity: Miles per hour	Maximum velocity: Direction	Maximum velocity: Date						
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
Northern Slope							48.0	+2.8										59	0.72	−0.3										4.1		
Billings	3,140	5	----	----	----	----	44.8	----	80	1	58	21	30	31	40	----	----	----	1.12	----	5	----	nw.	----	----	----	18	7	6	----	0.0	0.0
Havre	2,505	11	44	27.36	30.01	+0.03	47.5	+3.0	83	1	64	17	30	32	47	36	25	40	0.02	−0.6	2	6,033	sw.	34	nw.	26	20	7	4	2.8	T.	0.0
Helena	4,110	87	112	25.83	30.05	+.02	47.4	+2.5	73	2	59	27	11	36	37	38	28	52	0.09	−0.8	2	5,104	sw.	28	sw.	26	16	8	7	4.1	T.	0.0
Kalispell	2,973	48	56	26.99	30.07	+.06	44.2	+0.7	74	1	56	24	8	32	38	38	32	69	0.44	−0.6	5	3,106	nw.	28	sw.	23	15	7	9	4.2	T.	0.0
Miles City	2,371	48	55	27.50	30.07	+.07	49.4	+2.9	80	1	64	22	31	35	44	40	32	57	0.23	−0.6	3	3,857	s.	29	nw.	23	14	13	4	3.6	0.0	0.0
Rapid City	3,259	50	58	26.63	30.05	+.04	51.8	+3.3	84	1	64	16	31	40	44	41	32	54	0.79	−0.2	6	5,921	w.	35	nw.	29	17	6	8	4.0	0.7	0.0
Cheyenne	6,088	84	101	24.05	30.03	+.02	47.4	+2.6	75	1	60	22	30	35	37	38	29	55	1.07	+0.1	5	8,148	w.	53	w.	26	14	10	7	4.4	0.5	0.0
Lander	5,372	60	68	24.70	30.07	+.03	47.5	+4.0	76	1	61	25	27	34	30	39	33	66	1.62	+0.3	6	2,909	sw.	33	sw.	26	15	9	7	4.1	2.6	0.0
Sheridan	3,790	10	47	26.13	30.06	----	46.8	----	79	3	62	22	31	32	44	38	32	67	1.78	+0.7	5	2,659	nw.	25	nw.	26	15	12	4	4.0	T.	0.0
Yellowstone Park	6,241	11	48	23.94	30.11	+.09	42.0	+0.5	68	2	54	22	11	30	38	33	25	59	0.78	−0.6	6	4,151	sw.	31	sw.	23	10	10	11	5.3	1.4	0.0
North Platte	2,821	11	51	27.09	30.02	.00	55.0	+5.3	84	5	60	17	31	41	39	44	37	61	0.34	−0.7	7	4,868	s.	34	nw.	26	13	11	7	4.6	0.6	0.0
Middle Slope							60.6	+4.7										58	1.14	−0.6										3.9		
Denver	5,292	106	113	24.77	30.02	+.01	54.0	+2.8	84	9	66	23	30	42	42	41	29	46	0.63	−0.4	6	4,529	s.	33	w.	26	15	8	8	4.2	T.	0.0
Pueblo	4,685	80	86	25.34	30.01	+.02	56.1	+4.1	85	9	72	20	31	40	48	42	30	45	0.13	−0.5	3	3,881	nw.	34	w.	26	19	9	3	3.3	0.0	0.0
Concordia	1,392	50	58	28.57	30.04	+.01	60.4	+4.5	93	10	71	32	31	50	40	52	47	71	2.50	+0.5	8	5,790	s.	32	nw.	10	13	14	4	4.5	T.	0.0
Dodge City	2,509	88	100	27.45	30.04	+.02	61.0	+4.9	93	6	74	19	31	48	37	49	41	58	0.56	−0.7	4	9,180	s.	47	n.	10	23	5	3	2.7	0.0	0.0
Wichita	1,358	139	158	28.60	30.02	−.01	64.2	+5.6	94	6	74	30	31	55	31	54	48	63	1.19	−1.4	6	8,329	s.	48	s.	26	12	13	6	4.6	0.0	0.0
Oklahoma City	1,214	10	47	28.76	30.03	.00	68.0	+6.5	96	4	78	32	31	58	31	58	52	66	1.83	−1.0	9	5,897	s.	24	s.	26	15	8	8	4.1	0.0	0.0
Southern Slope							68.7	+5.5										58	2.88	+1.1										3.2		
Abilene	1,738	10	52	28.23	30.02	+.01	70.8	+5.4	98	7	82	40	31	60	30	60	54	67	10.21	+7.7	6	5,837	s.	26	s.	26	17	7	7	3.9	0.0	0.0
Amarillo	3,676	10	49	26.32	30.02	+.02	63.3	+5.6	91	5	76	32	31	50	36	50	42	57	0.92	−0.7	4	5,767	s.	22	sw.	26	23	3	5	2.5	0.0	0.0
Del Rio	944	64	71	28.97	29.94	−.04	77.2	+7.2	96	7	88	52	31	67	29	65	58	59	0.01	−1.8	1	5,608	se.	22	se.	11	18	10	3	3.4	0.0	0.0
Roswell	3,566	75	85	26.41	29.90	+.03	63.3	+3.8	90	6	78	31	30	49	41	50	39	50	0.37	−1.0	3	4,294	s.	27	nw.	20	19	9	3	2.9	0.0	0.0
Southern Plateau							62.9	+2.9										50	0.45	−0.2										3.2		
El Paso	3,778	152	175	26.20	29.93	+.01	70.0	+6.5	91	10	82	44	31	58	39	52	39	37	0.14	−0.7	2	5,497	e.	30	w.	20	22	7	2	2.1	0.0	0.0
Albuquerque	4,972	51	66	25.10	29.95	----	59.0	----	82	10	73	30	30	45	39	47	37	53	0.57	----	4	3,456	ne.	25	se.	11	22	5	4	3.1	0.0	0.0
Santa Fe	7,013	38	53	23.33	29.99	+.03	52.8	+2.4	73	10	64	27	30	42	30	42	34	56	1.10	−0.1	6	4,117	se.	21	n.	28	17	10	4	3.4	T.	0.0
Flagstaff	6,907	10	59	23.40	29.96	+.04	48.6	+3.9	70	3	65	21	31	32	46	38	----	63	1.43	----	5	4,938	nw.	26	sw.	18	18	11	2	----	0.0	0.0
Phoenix	1,108	10	107	28.75	28.89	+.01	72.8	+2.2	97	8	88	49	28	58	43	56	42	40	0.22	−0.2	1	2,661	e.	19	s.	9	23	6	2	1.9	0.0	0.0
Yuma	141	9	54	29.75	29.90	+.03	73.5	+0.2	97	4	88	49	20	59	40	58	48	48	0.09	−0.2	2	2,796	n.	21	nw.	18	26	4	1	1.1	0.0	0.0
Independence	3,957	6	27	25.97	29.99	+.04	59.5	+2.0	82	3	75	35	27	44	40	45	----	----	0.69	+0.4	2	----	s.	----	----	----	17	10	4	----	0.0	0.0
Middle Plateau							54.0	+3.8										48	0.60	−0.2										3.8		
Reno	4,532	74	81	25.48	29.97	−.02	54.8	+5.1	82	1	70	28	27	39	42	42	29	44	0.19	−0.2	1	3,708	sw.	42	sw.	25	18	11	2	2.9	0.0	0.0
Tonopah	6,090	12	20	----	----	----	54.6	----	78	3	64	30	26	45	28	42	30	45	0.48	----	3	----	se.	----	----	----	----	----	----	----	----	----
Winnemucca	4,344	18	56	25.64	30.02	−.03	51.8	+3.5	82	2	70	24	27	34	51	39	26	44	0.29	−0.3	3	4,832	ne.	36	sw.	22	20	7	4	3.1	T.	0.0
Modena	5,473	10	43	24.65	29.98	+.02	50.6	+2.6	76	16	65	23	27	36	44	40	30	55	0.87	+0.1	5	5,793	w.	35	nw.	26	14	10	7	4.0	0.0	0.0
Salt Lake City	4,360	163	203	25.65	30.00	−.01	56.6	+4.1	78	9	66	31	27	47	29	45	35	47	0.57	−0.9	5	4,809	se.	39	nw.	26	8	15	8	5.3	0.0	0.0
Grand Junction	4,602	60	68	25.42	30.00	+.01	56.4	+3.6	82	9	68	29	28	44	35	45	35	51	1.07	+0.1	6	3,422	se.	30	w.	26	17	8	6	3.6	0.0	0.0
Northern Plateau							51.6	+1.6										58	0.88	−0.2										4.6		
Baker	3,471	48	53	26.50	30.09	+.01	47.4	+0.8	76	1	61	25	21	34	42	39	30	55	0.41	−0.5	6	3,849	se.	23	se.	22	14	10	7	4.0	0.1	0.0
Boise	2,739	79	87	27.20	30.07	+.01	53.8	+2.7	81	2	66	35	21	42	36	44	34	53	0.43	−0.8	7	2,566	se.	18	n.	5	14	6	11	4.5	T.	0.0
Lewiston	757	40	48	29.26	30.08	+.01	52.8	+1.3	87	1	66	32	9	40	41	----	----	----	1.17	−0.1	8	1,574	w.	19	nw.	2	14	10	7	4.4	0.0	0.0
Pocatello	4,477	60	68	25.52	30.04	.00	51.2	+2.8	76	1	63	32	30	40	39	41	33	58	1.51	+0.4	8	4,516	se.	33	sw.	26	12	7	12	5.5	T.	0.0
Pasco	416	5	33	----	----	----	52.1	----	87	1	67	25	21	37	46	----	----	61	0.65	----	4	4,655	nw.	----	----	----	15	5	11	----	0.0	0.0
Spokane	1,929	101	110	28.01	30.07	+.01	49.4	+1.1	80	1	61	30	21	38	37	42	35	63	0.82	−0.4	7	2,982	s.	24	sw.	23	13	11	7	4.3	0.0	0.0
Walla Walla	991	57	65	28.98	30.05	−.02	54.0	+0.5	86	1	64	37	21	44	33	47	38	58	1.51	0.0	6	2,606	se.	20	se.	22	13	7	11	5.0	0.0	0.0
Yakima	1,076	58	67	28.90	30.06	----	52.4	+2.2	82	1	64	31	24	40	37	44	35	57	0.33	−0.3	7	2,950	nw.	24	sw.	22	16	8	7	4.2	0.0	0.0
North Pacific Coast Region							53.2	+1.0										78	3.63	0.0										6.3		
North Head	211	11	56	29.82	30.05	.00	52.8	−0.1	76	14	57	43	21	48	24	51	49	89	5.69	−0.7	14	9,268	n.	66	s.	21	6	7	18	6.9	0.0	0.0
Port Angeles	29	8	53	----	30.05	----	49.9	----	65	1	57	37	8	43	22	----	----	----	1.16	−1.2	11	3,454	s.	24	w.	26	8	8	15	----	0.0	0.0
Seattle	125	215	250	29.91	30.04	−.01	52.5	+1.1	69	15	58	40	21	46	25	49	47	81	3.00	+0.2	14	4,749	s.	30	s.	23	9	8	14	6.0	0.0	0.0
Tacoma	194	172	201	29.84	30.05	+.01	51.4	+0.9	71	16	58	37	8	44	28	----	----	----	3.93	+0.6	14	4,129	s.	26	n.	7	6	7	18	7.2	0.0	0.0
Tatoosh Island	86	9	53	29.92	30.01	.00	51.8	+1.9	64	15	55	43	10	48	14	50	48	89	5.76	−2.4	14	9,524	e.	47	s.	26	6	5	20	7.3	0.0	0.0
Medford	1,329	29	58	28.62	30.03	----	54.2	----	89	1	69	31	7	39	47	46	39	63	1.74	+0.4	8	2,906	s.	30	se.	21	13	10	8	4.7	0.0	0.0
Portland, Oreg	153	68	106	29.89	30.05	−.01	55.8	+1.6	79	15	64	39	21	48	28	51	47	76	4.32	+1.2	12	3,498	nw.	17	e.	29	7	10	14	6.1	0.0	0.0
Roseburg	510	75	99	29.51	30.06	−.02	54.7	+0.8	85	1	66	37	4	44	38	49	44	71	3.34	+0.7	10	2,257	n.	23	sw.	22	9	11	11	5.6	0.0	0.0
Middle Pacific Coast Region							59.7	−0.6										63	0.76	−0.5										4.2		
Eureka	62	73	89	30.00	30.07	+.01	53.6	0.0	68	29	59	42	26	48	20	51	49	86	2.28	0.0	7	3,348	nw.	34	sw.	22	6	8	17	6.6	0.0	0.0
Red Bluff	330	5	58	29.62	29.97	−.06	63.4	−0.9	98	1	77	40	26	50	41	52	41	49	0.57	−0.8	3	3,712	nw.	29	se.	22	19	6	6	3.4	0.0	0.0
Redding	722	20	34	----	----	----	64.9	----	96	1	76	40	26	54	30	----	----	42	3.13	----	3	5,099	nw.	----	----	----	15	7	9	----	0.0	0.0
Sacramento	69	106	117	29.91	29.98	−.01	62.0	−0.9	95	1	74	39	26	49	38	54	48	64	0.18	−0.7	2	4,515	s.	23	nw.	18	27	1	3	1.8	0.0	0.0
San Francisco	155	208	243	29.85	30.02	+.01	59.8	−0.7	83	1	66	49	26	53	26	53	50	76	0.68	−0.4	3	4,100	sw.	22	w.	10	9	13	9	5.2	0.0	0.0
San Jose	141	12	110	29.88	30.03	----	59.8	−0.5	92	1	72	30	27	48	42	----	----	----	0.10	−0.6	2	3,507	nw.	22	se.	22	18	7	6	3.8	0.0	0.0
South Pacific Coast Region							67.0	+2.6										61	0.04	−0.6										3.1		
Fresno	327	89	98	29.63	29.98	+.02	65.5	+1.5	93	2	79	42	27	52	37	53	41	47	T.	−0.6	0	3,513	nw.	26	nw.	25	23	7	1	2.1	0.0	0.0
Los Angeles	338	159	191	29.62	29.98	+.03	68.8	+3.5	94	28	78	52	10	60	29	57	50	61	0.06	−0.6	3	2,935	w.	20	ne.	1	18	5	8	3.3	0.0	0.0
San Diego	87	62	70	29.87	29.96	−.01	66.6	+2.9	93	1	74	54	27	60	29	60	56	74	0.05	−0.5	1	3,517	nw.	24	n.	1	15	13	3	3.9	0.0	0.0
West Indies																																
San Juan, P. R.	82	9	54	29.85	29.93	----	80.4	+0.6	92	21	86	73	28	75	18	----	----	----	6.40	+0.5	23	6,147	e.	40	e.	10	7	18	6	5.5	0.0	0.0
Panama Canal																																
Balboa Heights	118	6	97	----	[1] 29.80	−.02	80.4	+1.2	91	11	86	72	25	74	17	----	----	[1] 87	9.26	−0.9	20	3,879	nw.	24	s.	18	0	8	23	8.1	0.0	0.0
Cristobal	36	6	97	----	[1] 29.81	−.02	82.0	+2.2	91	16	88	74	25	76	16	76	75	[1] 83	20.42	+5.0	26	4,352	se.	25	n.	12	0	7	24	8.3	0.0	0.0
Alaska																																
Fairbanks	455	11	44	----	[2] 29.60	----	23.1	----	44	17	31	−10	26	15	27	----	----	81	0.82	----	10	1,922	ne.	15	sw.	15	6	4	21	----	4.6	2.2
Juneau	80	11	50	[2] 29.66	[2] 29.75	----	43.4	----	55	4	47	30	27	40	17	41	37	79	15.91	----	24	5,806	se.	28	se.	31	3	6	22	8.2	0.4	0.0
Hawaiian Islands																																
Honolulu	38	86	100	[2] 29.95	[2] 29.99	----	77.6	+0.8	85	11	82	68	29	73	15	71	69	76	2.33	+0.8	11	5,067	e.	24	ne.	21	7	14	10	5.7	0.0	0.0

[1] Observations taken bihourly.

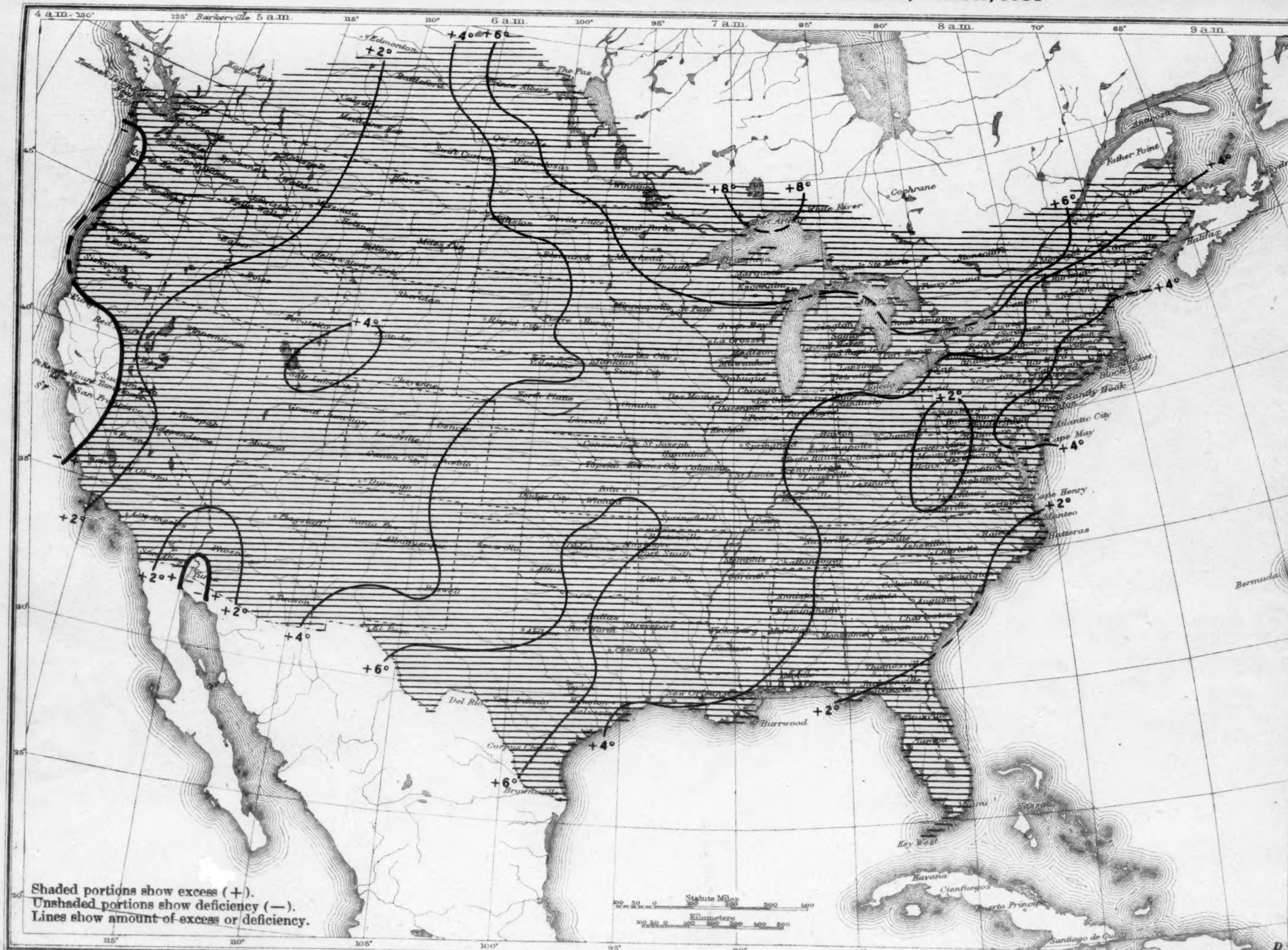
[2] Pressure not reduced to mean of 24 hours.

TABLE 2.—*Data furnished by the Canadian Meteorological Service, October, 1931*

Stations	Altitude above mean sea level, Jan. 1, 1919	Pressure			Temperature of the air						Precipitation		
		Station reduced to mean of 24 hours	Sea level reduced to mean of 24 hours	Departure from normal	Mean max.+mean min.÷2	Departure from normal	Mean maximum	Mean minimum	Highest	Lowest	Total	Departure from normal	Total snowfall
	Feet	*Inches*	*Inches*	*Inches*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	*Inches*	*Inches*	*Inches*
Cape Race, N. F.	99												
Sydney, C. B. I.	48	29.90	29.95	−.01	49.8	+3.3	58.0	41.7	72	32	2.44	−2.25	0.0
Halifax, N. S.	88	29.83	29.94	−.02	50.3	+3.1	58.2	42.3	69	31	3.80	−1.75	T.
Yarmouth, N. S.	65	29.83	29.90	−.12	51.1	+3.5	58.6	43.6	71	34	4.55	+0.43	0.0
Charlottetown, P. E. I.	38	29.82	29.86	−.10	49.4	+2.9	55.5	43.3	69	34	2.19	−2.71	0.0
Chatham, N. B.	28	29.81	29.84	−.12	47.5	+4.5	56.6	38.5	76	27	5.00	+1.14	0.0
Father Point, Que.	20												
Quebec, Que.	296	29.62	29.94	−.06	47.4	+5.0	54.4	40.4	75	31	4.49	+1.34	0.0
Doucet, Que.	1,236				42.9		52.7	33.2	77	17	4.17		3.1
Montreal, Que.	187	29.74	29.95	−.06	51.3	+6.5	58.1	44.6	76	35	3.91	+0.78	0.0
Ottawa, Ont.	236	29.71	29.97	−.04	52.2	+8.4	62.6	41.8	82	30	1.75	−0.80	T.
Kingston, Ont.	285	29.70	30.01	−.02	53.1	+6.1	60.1	46.1	73	32	2.51	−0.22	0.0
Toronto, Ont.	379	29.62	30.03	−.01	53.1	+6.5	61.1	45.2	77	34	1.99	−0.37	0.0
Cochrane, Ont.	930				46.2		54.4	37.9	78	27	3.75		T.
White River, Ont.	1,244	28.60	29.92	−.06	44.3	+7.2	54.4	34.3	76	18	3.49	+1.14	0.0
London, Ont.	808				52.7		62.9	42.6	80	30	2.06		T.
Southampton, Ont.	656	29.30	30.02	.00	52.6	+6.5	61.3	44.0	78	32	3.50	+0.33	T.
Parry Sound, Ont.	688	29.30	30.00	−.01	50.6	+6.7	57.8	43.4	75	30	3.77	−0.15	0.0
Port Arthur, Ont.	644	29.22	29.93	−.05	49.8	+9.9	57.1	42.5	73	31	7.80	+5.24	0.0
Winnipeg, Man.	760												
Minnedosa, Man.	1,690	28.12	29.95	−.02	43.9	+6.1	55.3	32.6	78	24	0.63	−0.57	T.
Le Pas, Man.	860				43.2		53.1	33.3	68	26	1.91		0.7
Qu Appelle, Sask.	2,115	27.66	29.92	−.05	43.6	+4.2	54.7	32.6	74	20	0.48	−0.62	T.
Moose Jaw, Sask.	1,759				45.4		58.3	32.4	77	18	0.39		0.0
Swift Current, Sask.	2,392	27.37	29.90	−.07	45.0	+2.9	59.5	30.5	78	8	0.16	−0.72	0.0
Medicine Hat, Alb.	2,365												
Calgary, Alb.	3,540												
Banff, Alb.	4,521	25.36	29.95	.00	40.8	+1.5	51.9	29.6	67	18	0.57	−0.45	3.1
Prince Albert, Sask.	1,450	28.36	29.95	−.02	43.8	+6.7	55.3	32.3	70	23	0.15	−0.68	T.
Battleford, Sask.	1,592	28.18	29.93	−.04	42.4	+2.8	55.6	29.2	73	16	0.49	+0.04	0.0
Edmonton, Alb.	2,150												
Kamloops, B. C.	1,262	28.72	30.02	+.06	47.0	0.0	56.1	38.0	78	30	0.52	−0.09	0.0
Victoria, B. C.	230	29.78	30.04	+.03	51.4	+2.2	56.4	46.4	68	43	1.77	−0.60	0.0
Barkerville, B. C.	4,180												
Estevan Point, B. C.	20				48.8		54.1	43.5	59	37	11.21		0.0
Prince Rupert, B. C.	170												
Hamilton, Ber.	151	29.96	30.12	+.10	74.7	+1.7	80.4	69.0	90	62	4.21	−2.50	0.0

Chart I. Departure (°F.) of the Mean Temperature from the Normal, October, 1931

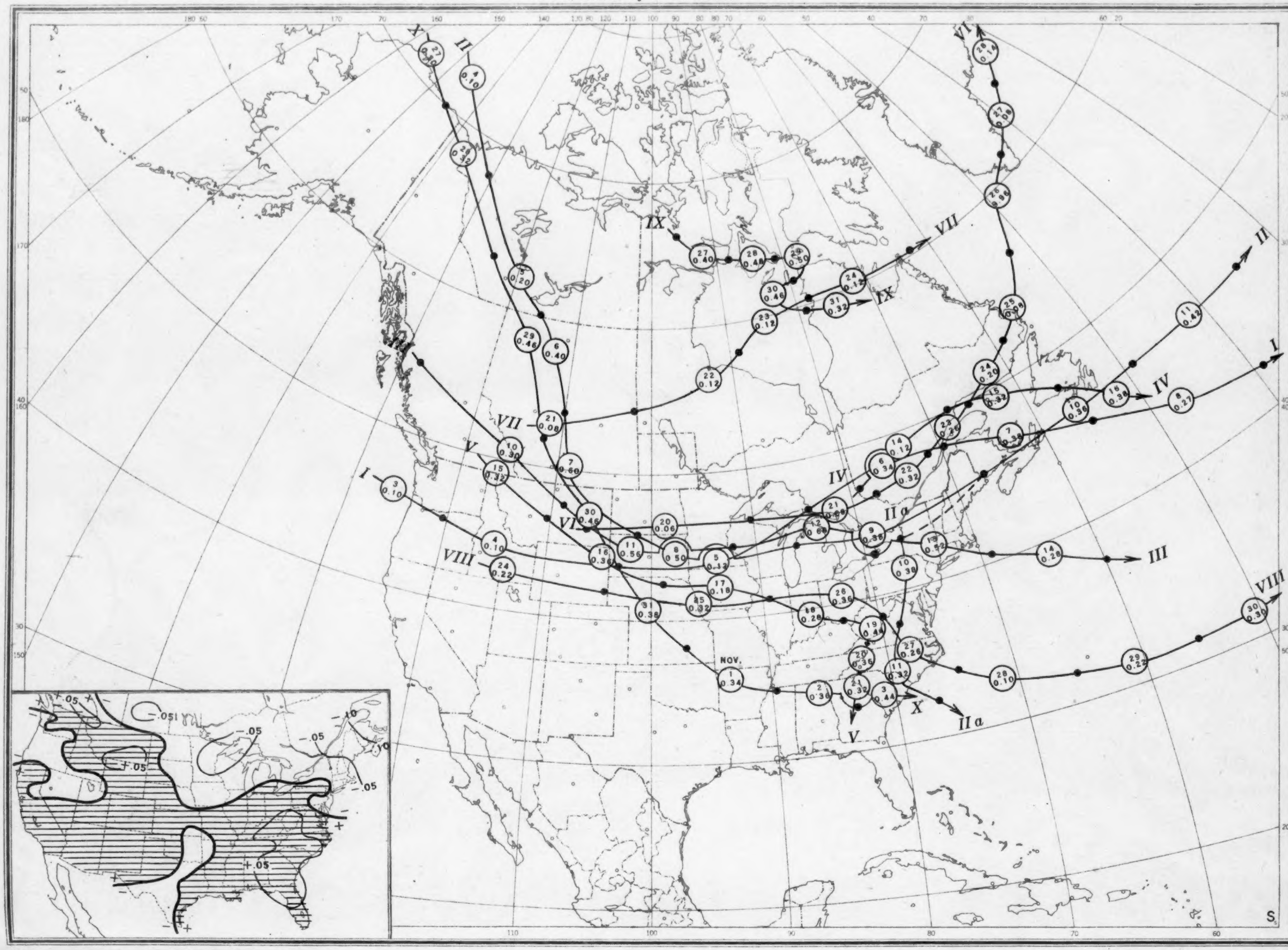
Chart I. Departure (°F.) of the Mean Temperature from the Normal, October, 1931



Shaded portions show excess (+).
Unshaded portions show deficiency (—).
Lines show amount of excess or deficiency.

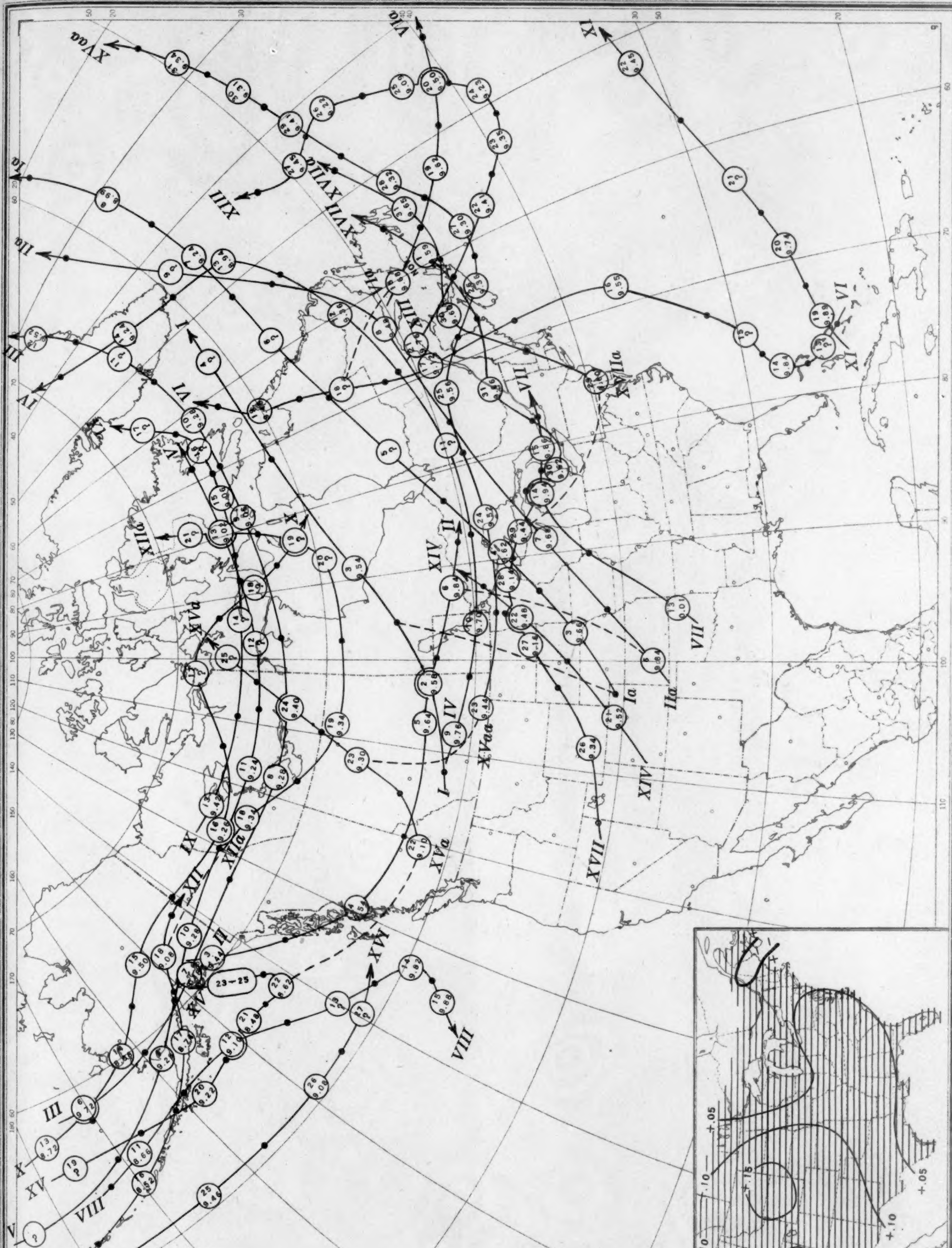
Chart II. Tracks of Centers of Anticyclones, October, 1931. (Inset) Departure of Monthly Mean Pressure from Normal

(Plotted by G. E. Dunn)



Circle indicates position of anticyclone at 8 a. m. (75th meridian time), with barometric reading. Dot indicates position of anticyclone at 8 p. m. (75th meridian time).

(Plotted by G. E. Dunn)



Circle indicates position of cyclone at 8 a. m. (75th meridian time), with barometric reading. Dot indicates position of cyclone at 8 p. m. (75th meridian time).

Chart IV. Percentage of Clear Sky between Sunrise and Sunset, October, 1931

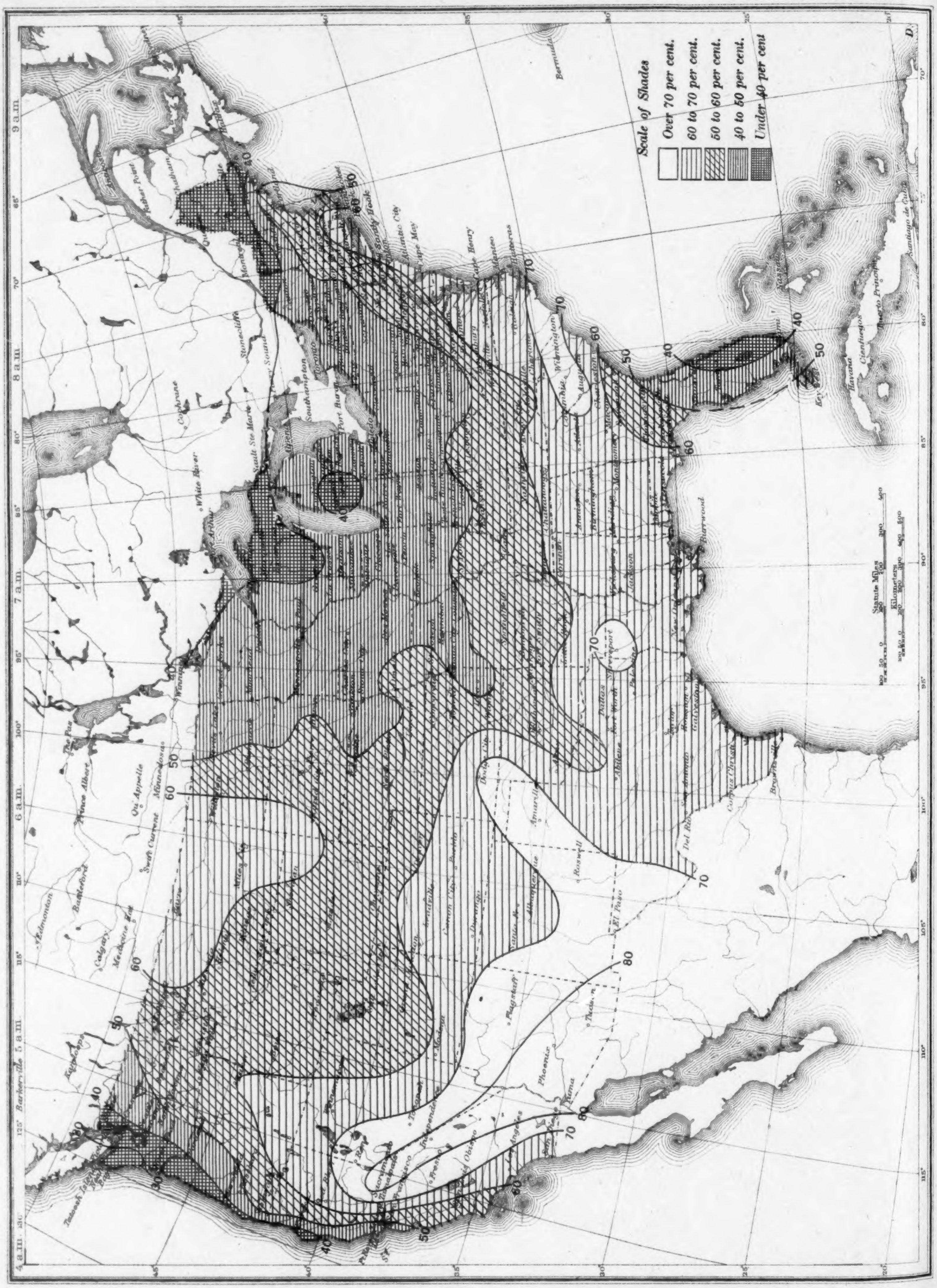


Chart V. Total Precipitation, Inches, October, 1931. (Inset) Departure of Precipitation from Normal

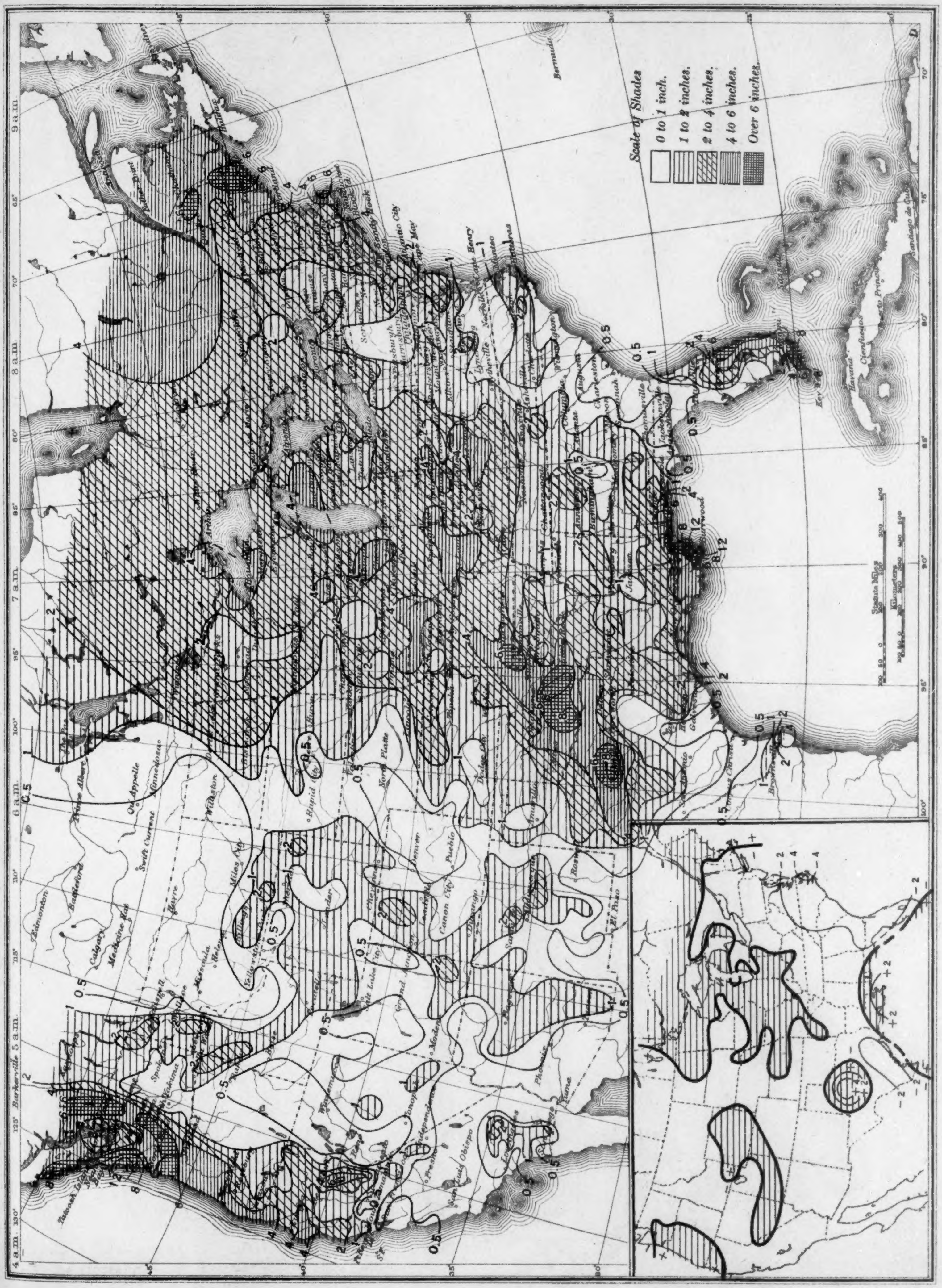


Chart VI. Isobars at Sea level and Isotherms at Surface; Prevailing Winds, October, 1931

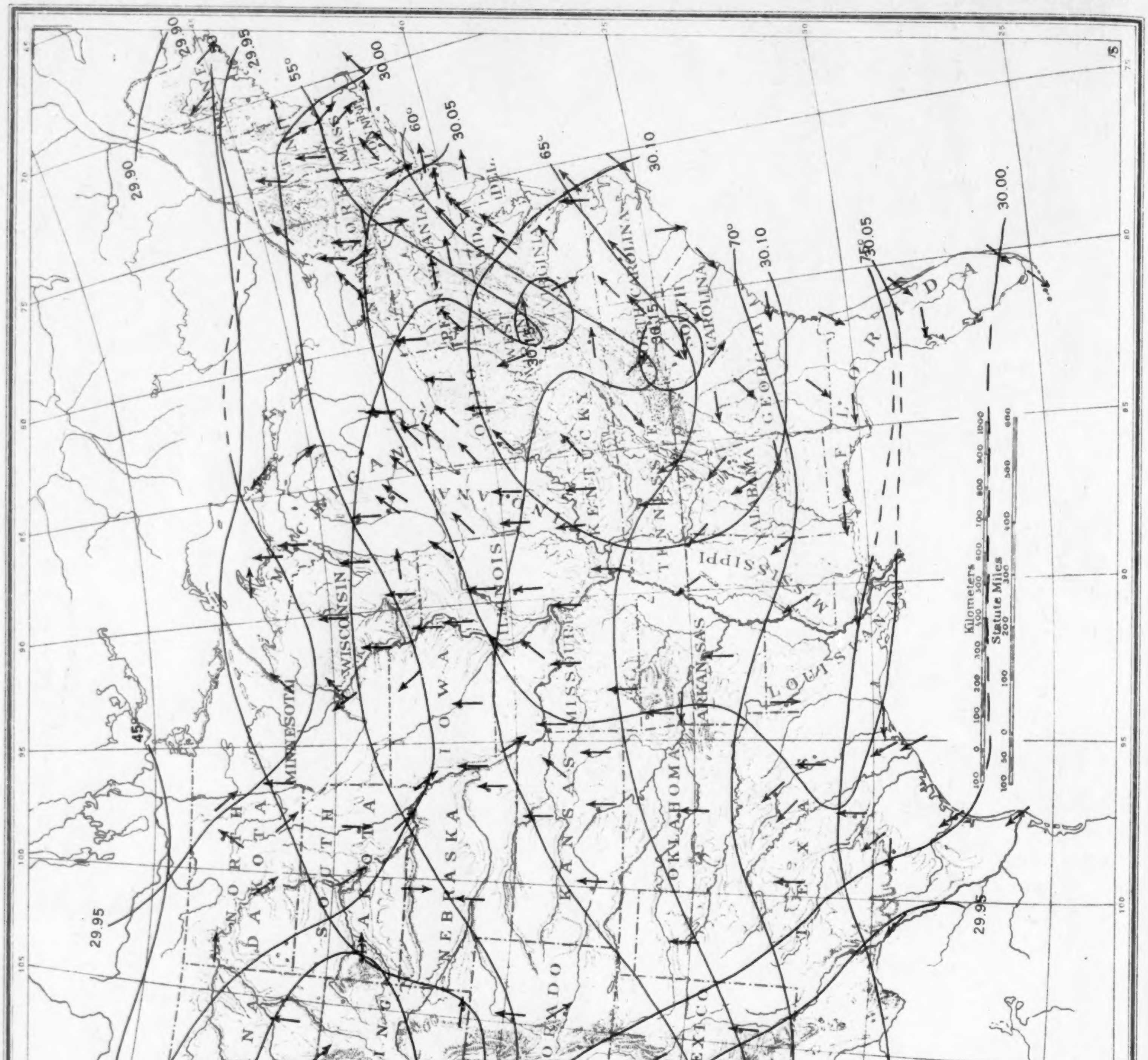


Chart VIII. Weather Map of North Atlantic Ocean, October 22, 1931
(Plotted from the Weather Bureau Northern Hemisphere Chart)

Chart VIII. Weather Map of North Atlantic Ocean, October 22, 1931

(Plotted from the Weather Bureau Northern Hemisphere Chart)

MORNING OBSERVATIONS

(Between 700 and 1300, G. M. T.)

Isobars show corrected barometric readings in inches of mercury.

Arrows fly with the wind.

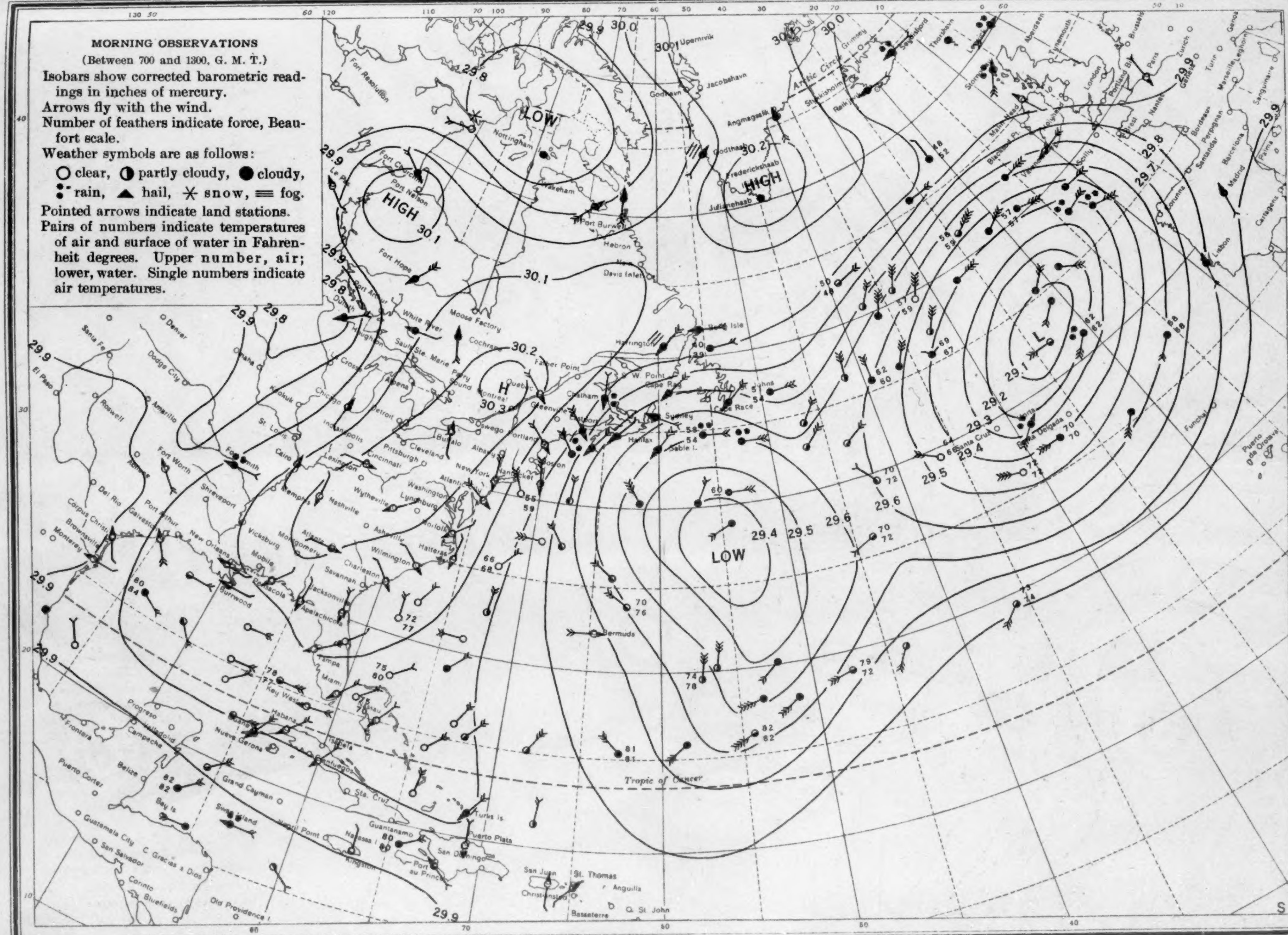
Number of feathers indicate force, Beaufort scale.

Weather symbols are as follows:

○ clear, ◑ partly cloudy, ● cloudy, ⁖ rain, ▲ hail, ✳ snow, ≡ fog.

Pointed arrows indicate land stations.

Pairs of numbers indicate temperatures of air and surface of water in Fahrenheit degrees. Upper number, air; lower, water. Single numbers indicate air temperatures.



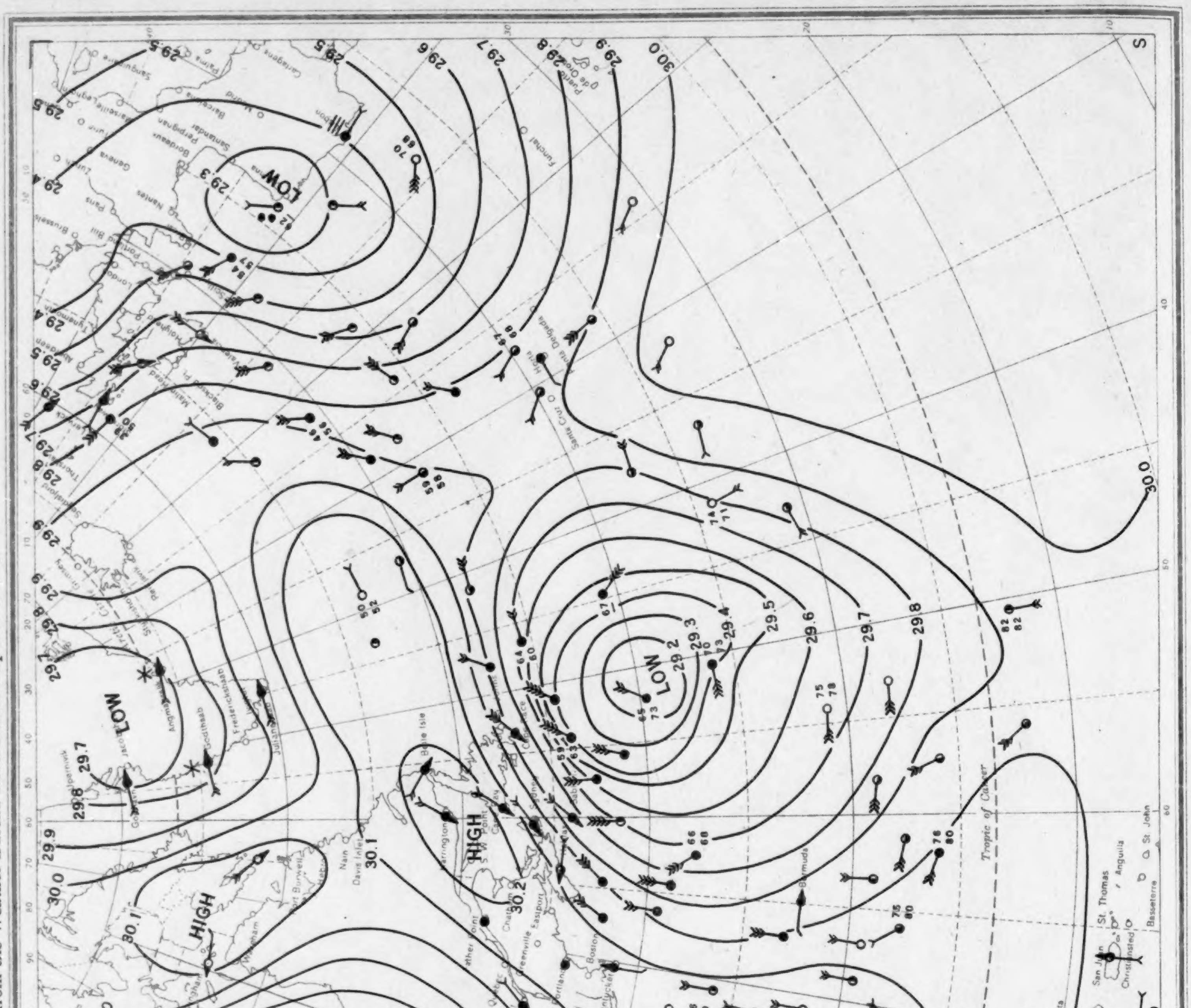


Chart IX. Weather Map of North Atlantic Ocean, October 24, 1931
(Plotted from the Weather Bureau Northern Hemisphere Chart)

Chart X. Weather Map of North Atlantic Ocean, October 26, 1931
(Plotted from the Weather Bureau Northern Hemisphere Chart)

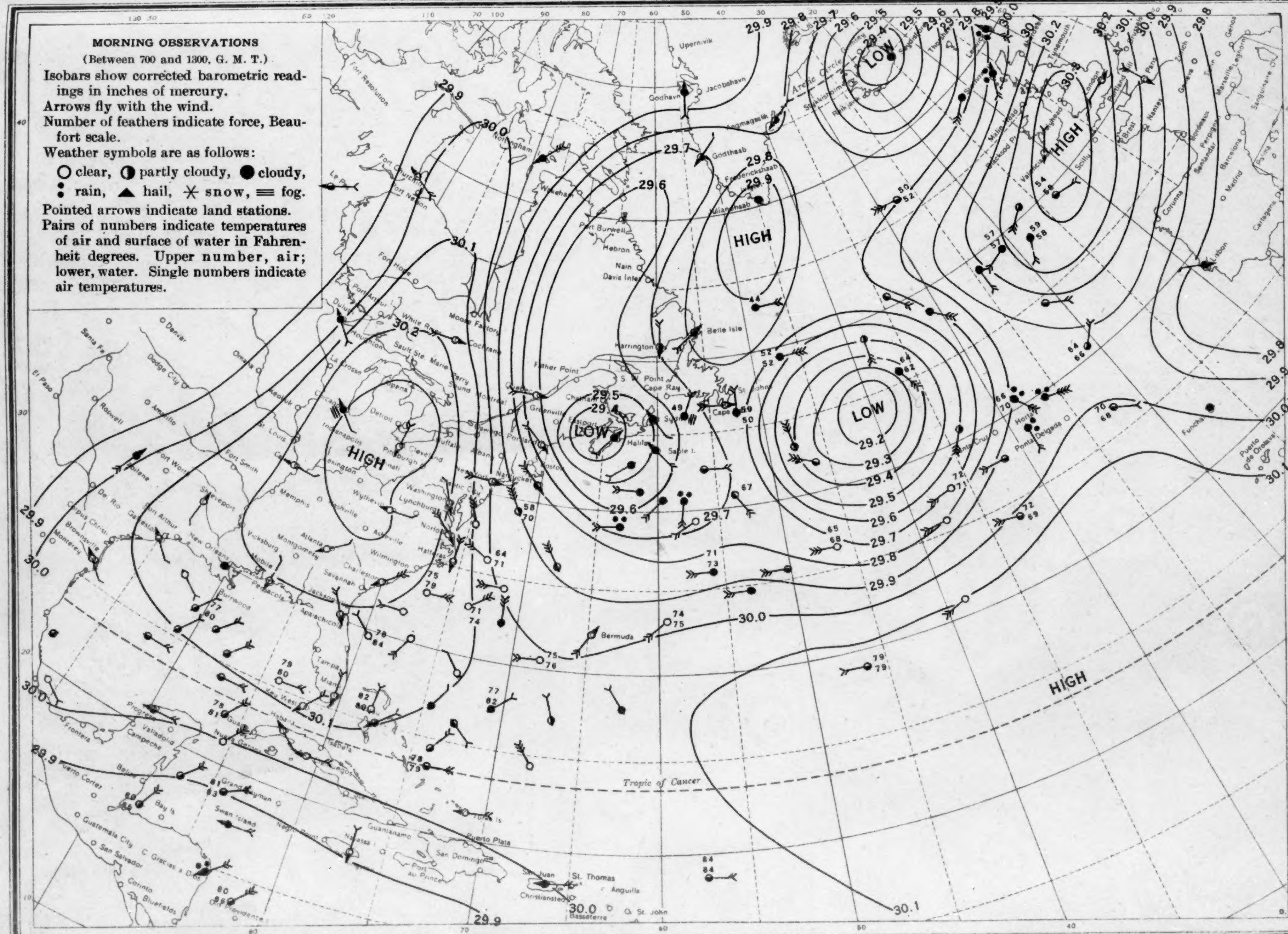


Chart XI. Weather Map of North Atlantic Ocean, October 28, 1931

(Plotted from the Weather Bureau Northern Hemisphere Chart)